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THE DISCOVERY OF THE *CELL OF SCHWANN* IN 1839

BY FRANCIS TH. MÜNZER, M.D.

Docent of Neurology, German University, Prague

"Even though to aspiring Youth, bent on the creating of nothing less than a new World-epoch, the past appears irksome rather than inspiring, nevertheless those of riper mind and years must often accord their grateful recognition to the manifold Good and Useful and Helpful that they have inherited from their Ancestors". (Goethe, Materialien zur Geschichte der Farbenlehre.)

I

IN 1839 Theodor Schwann (1), in his famous *Microscopical Researches into the Accordance in the Structure and Growth of Animals and Plants*, described for the first time those cells of the peripheral nerve fibers which ever since have been known by his name. Schwann also endeavored to grasp their origin and meaning, and as the fruit of his efforts conceived the so-called cell-chain theory of the development of nerve fibers. He thus became the creator of a hypothesis which was to find many adherents, and which has to the present day retained some of its former importance. Other hypotheses have indeed been advanced since, of which mention may be made of the outgrowth theory, as advanced by Kupffer and Bidder, and Hensen's protoplasmatic-bridge theory.

So it may seem not inappropriate, if, on the hundredth anniversary of the first description of the Schwann cell, due homage is paid to its discoverer by a commemoration of what he achieved in the field of neuro-histology.

Theodor Schwann, the fourth son of a bookseller, was born at Neuss on the Rhine on December 7, 1810. In 1829 he began to study philosophy and medicine, first at the University of Bonn and later at Würzburg and Berlin. From 1834 to 1839 he worked in Berlin—simultaneously with Jakob Henle—as an assistant to the physiologist Johannes Müller. In 1839 he was appointed professor of anatomy at the University of Louvain and nine years later went in the same capacity to Liege. From 1858 he also occupied the chair of physiology. In 1880 he retired from his academic activities, and died in Cologne on January 11, 1882.

At the age of twenty-nine he wrote his epoch-making *Microscopical Researches*,

which, in the words of K. Sudhoff (33), "represent a conspicuous milestone in nineteenth century biology," and he thereby ranks as one of the originators of the cell-theory.

As J. Henle (31) says in his necrology on Schwann, he applied himself as early as 1836–1839 to the problem of the regeneration and termination of the nerve fibers. But the sheath of Schwann and the Schwann nuclei, both of which are named after him, found their first description in the *Microscopical Researches*.

II

It is perfectly clear, however, that the investigations carried out by Schwann also denote a milestone in the history of neuro-histology. At no time before the appearance of the universal cell theory had an acceptable explanation been offered of the elements constituting the nervous system, and of their meaning. Here, for the first time, the idea was clearly formulated (and an attempt made to corroborate it by minute proofs) that the whole of the animal organism was built up by, and consisted of, nothing else but cells.

Theodor Schwann devoted a large part of his investigations to the nervous system of which the forms of elementary structure (*Elementargebilde*) presented themselves to him in a twofold manner: "1st, fibers, nervous fibers in the extended sense of the term, including the fibers of the brain and spinal cord; 2nd, globules, ganglion-globules, in addition to the ganglia occurring in the brain and spinal cord" (p. 141, 142:—This, like all the other quotations, are taken from the English translation by Henry Smith. *Vide* Literature cited, No. 1). To him the principal task of his neurological research work consisted in pointing out "the relation which these two forms of elementary structure bear to the elementary cells" (p. 142). Such an enterprise at *his* time was bound to meet with the greatest difficulties, if concerned with nerve tissue, as it will still meet with certain obstacles today, when directed to the *peripheral* nerve fiber. Of such complications Schwann was perfectly aware, when he wrote: "In general, the higher the importance of a tissue is, the more do the cells lose their individuality" (p. 64).

He was the first to give an adequate explanation of the ganglion-globules by defining them as true cells. They are, in Schwann's own words "simple cells. The parenchyma of the ganglion-globules forms the cell-contents, and the vesicle in their interior is the cell-nucleus; the small corpuscles which it contains are the nucleoli. The vesicle of the ganglion-globules lies, as in other cells, eccentrically upon the internal surface of the cell-membrane. This cell-membrane may be most distinctly observed in the ganglion-globules of the sympathetic nerves of the frog, previous to their junction with the sacral plexus. [See Fig. I*a*—I am greatly indebted to Miss H. Rauchberg for her most faithful copies of this and the following figures from the originals.] It there appears comparatively dark, and sharply defined, both externally and internally, so that its thickness may be readily measured" (p. 153).

But Schwann, rather oddly, appears to believe that "in the situation before mentioned in the frog, it seems as though a ganglion-globule were sometimes formed within another cell" (p. 153) and, as a reason for his assumption, refers to Fig. 10*b* (our Fig. 1*b*), which, however, is an obvious case of shrinkage.

In accordance with Robert Remak, he distinguishes between two different forms of nerve fibers: (a) the *common white nerve fibers*; (b) the *gray*, or so-called *organic fibers*.

The white color of the *white* dark-

edged nerve fibers is conceived by Schwann as being caused by the same substance which, "when examined microscopically, exhibits very dark margins." "The margin of a fiber generally presents a double outline on both sides, so that it has the appearance of a hollow tube, and the distance between the two outlines, then, denotes the thickness of the white substance" (p. 142). The axis cylinder had been previously singled out by Remak. Schwann continues: "According to the researches of Remak, the white substance of every nervous fiber may be removed by pressure, and an extremely pellucid, pale

FIG. 1. GANGLION-GLOBULES FROM THE LOWEST GANGLIA OF THE SYMPATHETIC OF A FROG
Magnified about 450 diameters, linear measurement. After Schwann (1), Plate IV, Fig. 10.

band, which was previously surrounded by the white substance, then remains, corresponding to that which, previous to the manipulation, seemed to be the contents of the tube. . . . Two opinions with respect to the nervous fibers may be deduced from the above observations; either this pale band is the proper nervous fiber, and the white substance only a sheath (cortex) around it (this is the view taken by Remak), or the nervous fiber is actually a hollow fiber, the wall of which is formed by the white substance, the contents of which, however, are not fluid, but composed of a tolerably firm substance, namely, the above-mentioned band" (p. 142).

The pertinent passage describing the *sheath*, since known by his name, *and its nuclei*, runs as follows:

> It seems that the expression *neurilemma*, to denote the sheath of Schwann, had its origin with E. Reissner (30), while most earlier authors had applied this term to the connective tissue (epineurium) enveloping the nerves, the lamellae (perineurium) radiating thence into the interior, and the tender tracts of connective tissue (endoneurium) occurring within the minor nerve stems. The relating passage by Reissner (p. 726) reads: "The hardened, carmine-stained and turpentine-cleared preparations of cross-sectioned nerve fibers display the crimson primitive sheath, which I call neurilemma because of its correspondence with the sarcolemma, the axis cylinder, mostly in the same color, and the transparent myeline, which as a rule remains colorless."

"The white substance of each nerve is surrounded externally with a structureless and peculiar membrane, which appears to be minutely granulated. This membrane presents itself as a narrow, clear border, which is really distinguished from the dark contours of the white substance. This membrane seems hitherto to have been included with the neurilemma or with the cellular tissue, which surrounds the nervous fiber, and although its external outline is generally very sharply defined in the nerves of the frog, it would be difficult, on examination of the entire nerve of a mammal, to arrive at any conviction of its distinct and separate existence, did not opportunities of observing it in an isolated state present themselves. Pl. iv, fig. 9*a* [our Fig. 2*a*] represents such a preparation, taken from the cranial portion of the nervus vagus of a calf. The continuity of the white substance has here been broken by the process of preparation; but where it still exists, the double contours, (and thus the thickness of the white matter), may be clearly distinguished. But the nerve still exists at the part where

the white substance is separated, its sharply-defined external margins may be seen, although their contours are but pale, and it may be observed that this pale outline does not pass into the external dark one of the white substance, but is continued on the outside of it as a narrow border, parallel to the two outlines of the white substance. The white substance of nerve is, therefore, surrounded externally with a thin, pale membrane, which has a sharply defined external margin. If the

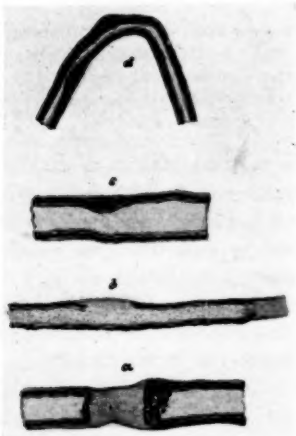


FIG. 2. NERVOUS FIBER FROM THE VAGUS OF A CALF Magnified about 450 diameters, linear measurement. After Schwann (1), Plate IV, Fig. 9.

membrane be very thin, it cannot be recognized as the pale border round the nervous fiber; it is still, however, distinctly visible at situations where the white substance is destroyed. (See fig. 9, *b* [our Fig. 2 *b*]). The mere fact of the membrane possessing a defined external border, is evidence against its being composed of areolar tissue; and even the portion which does not contain any white substance, presents no appearance of fibrous structure; it simply appears to be somewhat minutely granulated. If this be correct, the membrane can have no other signification than that of cell-membrane of the nervous fiber, or secondary nerve-cell. The white substance is then a secondary deposit upon its inner surface. The position of the cell-nuclei is also favorable to this view" (p. 146, 147).

As to the nuclei, he gained the impression that most of them disappear on the increasing development of the white substance: "Some, however, appear to remain for a longer period; occasionally, although rarely, a cell-nucleus is here and there seen upon the side of a nerve (the white substance of which is completely developed), lying in the pale border, which surrounds the white substance. Fig. 9, *c* and *d* [our Fig. 2, *c* and *d*], exhibits them from the nervus vagus of a calf. At *c* the white substance, corresponding to the nucleus, even forms a slight projection into the cavity of the fiber. This nucleus seems therefore actually to belong to the fiber, and to lie upon the inner surface of the cell-membrane, while the white substance is so deposited, that the nucleus remains situated external to it. The band discovered by Remak would then be the proper cell-contents" (p. 147).

Schwann also came to believe that the relation between the myeline-sheathed nerve fibers and the cells would have to be elucidated by the *history of their development*, and he examined the formation of the nerve fibers in the foetal pig. Completing and continuing the studies of Remak he reports that the nerves of the foetus "have not the shining white colour, presented by those of the adult animal, but are gray and transparent, and the younger the embryo the more striking are these appearances" (p. 143). The greater part of the nerves in a foetal pig of about six inches in length "does not form connected fibers, but consists of separate round globules"—Schwann regarded these struc-

tures "as an artificial product, caused by pressure and the action of water upon the as yet very delicate nerve" (p. 148) "— or more or less long, irregular little cylinders, arranged with their long axes in the direction of the course of the nerves, having outlines, however, quite as dark as those of the nervous fibers. . . ." "In addition to them, however, a substance of quite another appearance is seen, which has not the dark outline, does not appear pellucid but granulated, and in which the *cell-nuclei* [my italics] are distinctly rec-

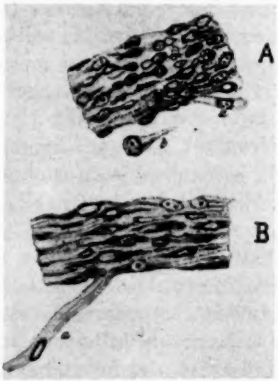


FIG. 3. (A) PORTION OF THE ISCHIATIC NERVE OF A FOETAL PIG MEASURING FOUR INCHES. (B) FASCICULUS OF NERVOUS FIBERS FROM THE BRACHIAL PLEXUS OF THE SAME
After Schwann (1), Plate IV, Figs. 6 and 7.

ognisable." ". . . When the other constituent parts predominate, the nuclei may very probably be overlooked, or possibly be regarded as extraneous substances" (p. 143, 144).

"The development of nerve, however, does not appear to proceed uniformly in all individuals; for the dark globules and cylinders were already present in some other pigs' embryos, which were scarcely any larger. Pl. 4, fig. 6 [our Fig. 3 A] represents a portion of the ischiatic, and fig. 7 [our Fig. 3 B], of the brachial nerve of such a foetus. We observe a palish, and very minutely-granulated cord, which, in consequence of certain longitudinal shadings, such as the delineation exhibits, presents the appearance of a coarse fibrous structure. Round or for the most part oval corpuscles, which are immediately recognized as cell-nuclei, and which sometimes also contain one or two nucleoli, are generally seen in the course of these shaded parts, throughout the entire thickness of the cord. Sometimes a fiber separates from such a cord, and stands out isolated, as at *a* in both the figures, and the nuclei are then seen to lie in the course of the fibers. A single fiber presents several nu-

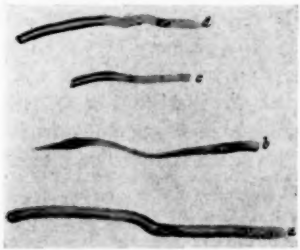


FIG. 4. SINGLE NERVOUS FIBERS. *a*, FROM THE NERVOUS TRIGEMINUS OF A FOETAL PIG MEASURING SIX INCHES AND A HALF; *b*, *c*, *d*, FROM THE NERVOUS ISCHIADICUS OF THE SAME
After Schwann (1), Plate IV, Fig. 8.

clei in its course, as was also observed in secondary muscle-cells" (see Fig. 4 *b*). ". . . Although the (nervous) fibers cannot at this early period be distinctly perceived to be hollow, the wall not being distinguishable microscopically from the contents, yet we shall see that the progress of development renders it highly probable that they are so" (p. 144).

Schwann supposes, on the analogy of the development of the muscle-cells, that the nerve fibers "are formed by the coalescence of primary cells, to which the nuclei, just noticed as present upon the fibers, have pertained; so that thus the nervous fibers would be secondary cells, corre-

sponding to the secondary muscle-cells, or primitive muscular fasciculi. The actual observation of the primary cells of nerve in their independent state, is very difficult, from the circumstance of our being unable at that period to distinguish between them and the surrounding tissues; for a whole organ is then composed entirely of independent cells, which have not as yet undergone any transformation. It is true," he writes, "I saw an independent cell, furnished with a nucleus, which seemed to have separated from the nervous cord, in one of the preparations alluded to, fig. 6, *b* [our Fig. 3 A, *b*]; but I cannot positively assert that it had actually separated from that particular part, nor that it was a primary nerve-cell, for the cells in that preparation had not as yet undergone any change. In this instance, therefore, we must content ourselves, for the present at least, with the analogy to muscle" (p. 144, 145).

"These fibers, or secondary nerve-cells, differ very much in their appearance from the subsequent nervous fibers, which are furnished with distinct but not dark outlines; they have a pale, granulated aspect. By progressive development, however, they become converted into the white fibers, and pl. iv, fig. 8, *d* [our Fig. 4, *d*] represents the transition. The part of the figure to the right hand exhibits the fiber yet in the early condition, pale, granulated, and furnished with a cell-nucleus; in the portion to the left, it has completely assumed its subsequent form: it has a dark outline, is not granulated, and the one portion passes immediately into the other. The identity between these pale fibers and the subsequent white nervous fibers is thus established" (p. 145).

The transformation of the granulated fibers into the white nerve fibers consists in the "development of the white substance." This process could, in the opinion of Schwann, be explained in a threefold manner: "It may take place, 1stly. By the white substance forming as a sheath (cortex), around each fiber, and in this manner enclosing it. By this mode of explanation the fiber would be identical with the pale band discovered by Remak, which would therefore be the cell-membrane itself. 2dly. The white substance might be regarded as a transformation and thickening of the cell-membrane of those fibers, or secondary nerve-cells. According to this view, the white substance would be the cell-membrane, and Remak's band the firm contents of the secondary cell. 3dly. The white substance may be formed as a secondary deposit upon the inner surface of the cell-membrane, being chemically distinct from the latter, and the remainder of the cell-cavity may then, and not until then, become filled up by Remak's band" (p. 145, 146).

Personally, Schwann inclines to, and advocates, the third view; he holds that the myeline is a secondary deposit on the interior surface of the cellular membrane.

"According to the foregoing explanation, therefore, each nervous fiber is, throughout its entire course, a secondary cell, developed by the coalescence of primary nucleated cells. With respect to these cells, we remark, 1stly. An external, pale, thin cell-membrane, having a granulated but not a fibrous aspect, the inner surface of which constantly exhibits cell-nuclei in the very early period of the development of nerve; but in the somewhat more advanced stage, when the white substance is developed, they are only occasionally found. 2dly. That the white, fat-like substance to which the peculiar appearance and distinct outline of the nerves are chiefly referable, is deposited upon the inner surface of this cell-membrane. When this deposit is thick, its double contour (to which the nerve is

indebted for its tabular appearance), may be recognized; this, however, escapes observation when only a thin stratum of white substance is present. Morphologically considered, it therefore corresponds to the peculiar substance of muscle, for that is likewise developed as a secondary deposit upon the membrane of the secondary muscle-cell. 3dly. That the rest of the cell-cavity appears to be filled up by a firm substance, namely, the band discovered by Remak. There seems to be no structure analogous to this band in perfectly-developed muscles, for there, the secondary deposit, that is, the formation of the proper muscular substance, proceeds until the cavity of the secondary cell is completely filled" (p. 147, 148).

As regards the *gray*, or *organic nerve fibers*, Schwann has nothing to add to the description given by Remak (cf. particularly Remak, 14, p. 5) with whom he almost wholly agrees. The corpuscles (*Körperchen*) attached to those fibers, which had been observed by Remak, he recognized at once as cellular nuclei. He also pointed out a certain resemblance between the organic fibers and "the earlier condition of the white nervous fibers, as they were represented in pl. IV, fig. 8, *a*, *b* [our Fig. 4, *a*, *b*]. Both have the same pale, minutely-granulated appearance, and both present cell-nuclei in their course. The only difference is, that the organic fibers are much more minute and the nuclei smaller. Each single nucleated organic fiber . . . corresponds to a white primitive fiber, and is probably, like it, a secondary cell, which has been generated by a coalescence of primary cells, whose nuclei are the nodules described by Remak as existing upon these fibers" (p. 151, 152).

The continuation of this passage runs as follows: "The similarity between the organic fibers and that which I have described as the earlier condition of the white nerve fibers, might be adduced as an objection to my description of the formation of nerves, and it might be said, that that form seemed to be the earlier form of the white nervous fiber, because the organic nerves were developed earlier than the white, and, therefore, organic fibers were the only ones present in the first instance. Observation of the actual transition, as represented in pl. IV, fig. 8, *c*, *d* [our Fig. 4 *c*, *d*], would, however, refute this argument. Each pale, nucleated fiber becomes a white nervous fiber, as an immediate consequence of the formation of the white substance, which is probably a secondary deposit upon the internal surface of the hollow fiber. The information of this white substance, which, according to analogy, must occur in every one of the minutest fibres, either does not take place at all in the organic fibres, or does so at a much later period, and their peculiarity therefore consists in their remaining stationary at an earlier stage of development, and either never attaining to the higher development of ordinary nerves, or only at a much later period, (a point which might be decided by comparing their numbers in old and young individuals). One can conceive that the function of the organic nerves, whether it be actually a chemico-vital one, or consist merely in the production of involuntary motion, requires less-developed nerves, in the same way that the involuntary muscles do not attain the same degree of development as the voluntary."

Summing up his view on the origin and development of nerves, Schwann concludes: "The growth of nerves neither proceeds from the circumference towards the central organs, nor *vice versa*, but their primary cells are included amongst those from which every organ is formed, and which, so far at least as their appearance is concerned, present no marks by which they can be distinguished from other cells. They are first characterized as nerves, when they become arranged in rows and coalesce to form a secondary cell. After that coalescence each nervous fiber forms a separate cell, which pursues an uninterrupted course from the organ, in which its peripheral extremity is situated, to the central organ of the nervous system" (p. 149).

Having reproduced here in his own words, whenever possible, such passages

of Schwann's treatise as might prove of any moment or interest to neurologists and neuro-histologists, we think that the importance of these observations will afford a sufficient justification for quoting them. Still there remains the striking fact that to the question of the relation between ganglion cell and nerve fiber—which even as early as in his time had undergone a certain amount of discussion—Schwann never paid the slightest attention.

III

Today it is impossible to gauge or to realize the tremendous achievement accomplished by Schwann and the inherent importance of his discovery, unless we take into account the state of such contemporary knowledge as existed before the appearance of his *Researches*. That is why a terse, roughly sketched outline of its historical development, from the discovery of nerve fibers and nerve cells up to the time of Theodor Schwann, may be permitted at this juncture.

I think there is good reason why the reader's attention should be drawn to those fundamental publications which, though most of them have long been forgotten, are nevertheless noteworthy for having impressed their stamp upon the early development of neuro-histology. In the interests of objectivity, I would add that the originals of the most important works have been at my disposal. Those who work in the field of neuro-histology may well profit by a fuller acquaintance with the soil they help to cultivate; for only thus can be seen the earlier yield—and the defects of the soil. In this way it is easier to understand why certain erroneous notions pass like an inheritance from one generation to another; how certain terms, once they have taken root, perpetuate their influence—I need merely mention expressions like: nerve tubes (*Nervenröhren*), nerve sheaths (*Nervenscheiden*), myeline sheath (*Markscheide*). Such terms, however, which can only be understood in the light of their origin, appear inappropriate and liable to form a hindrance to further progress—as will appear in my forthcoming publication.

We cannot say with any certainty who was actually the first to observe the myelinated nerve fibers. There is a common supposition that they were discovered by the Italian physician Felice Fontana (4) (born on April 15th, 1720, at Pomaroli near Rovereto, died on February 9th, 1805, at Florence) who, in 1781, from observations made on tease preparations described the peripheral nerves as being "composed of transparent, homogeneous, uniform, very simple, cylinders" (p. 371: —This and the following quotations are translated from the German edition of Fontana's book, which appeared in 1787; Literature cited, No. 4, b).

Now it is quite true that, according to the statement of Fontana himself (4, p. 357), as early an observer as Antonius van Leeuwenhoek (1632–1723), the originator of microscopical anatomy, is said to have noticed the fibrillar structure of nerves, and, on microscopical examination of a very delicate nerve no thicker than a hair, to have counted sixteen *small nerve tubes* (*Nervenröhrchen*), very distinctly marginated and filled with transparent contents. Leeuwenhoek seems to have maintained the view that those small nerve tubes consisted of nothing but a membrane of liquid contents. His statement, however, was contradicted by almost all subsequent investigators, who—obviously on inspecting heavily crushed nerves under water—could not see anything but a mass of granules and globules, which they took for the ultimate elements of the nervous system. But the

great physiologist A. von Haller had already displayed great reticence in his criticism of those observations of the nerve structure, and admitted that "nothing but mere conjectures could be offered on this subject. He was, however, inclined to believe that there might exist in the nerves some kind of tubular structure" [cited according to Fontana (4 b), p. 357].

Fontana also mentions the names of two contemporary observers, who engaged in microscopical research of the nervous system: Father Della Torre (2) and Professor Prochaska (3) of Prague. But their statements damaged more than

methodical research was able to establish that "the nerves appear to be composed of filaments, parallel and sinuous, just as they are shown in" (p. 365) the drawing here reproduced as Fig. 5.

Those single fibers or cylinders, of evenly uniform thickness, wavily and sinuously arranged within the nerve, when observed in the teased preparations appeared "to be more or less transparent, composed of small pellicles, and partly filled with a gelatinous, pellucid humor and small globules or irregular corpuscles" (p. 368). For these cylinders Fontana introduced the term *original nerve cylinders*

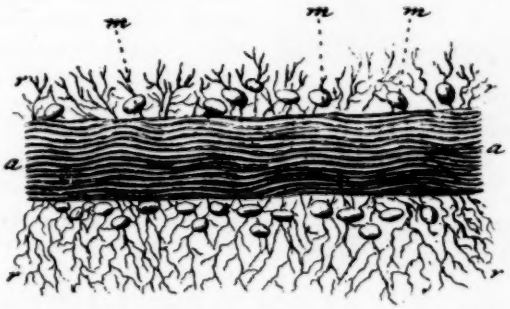


FIG. 5. FIGURE ILLUSTRATING A NERVE COVERED WITH ITS CELL-TISSUE, AS IT APPEARS THROUGH A VERY FEEBLE LENS. *aa*, THE TWO NERVE ENDS; *m*, OVAL GLOBULES WHICH MAY BE OBSERVED WITHIN THE CELL-TISSUE; *r*, FIBERS OF THE CELL-TISSUE FLOATING IN THE WATER
According to Fontana (4), Plate III, Fig. 11

they advanced the progress of science, "for they spread the erroneous notion of the brain being a pulpy mass that consisted of granules floating in a sticky, clear colored liquid, and partly lying side-by-side here and there." [Quoted from Ehrenberg (6, p. 448–449), who quite rightly attributes Della Torre's statement to the fact that "on being examined between mica scales or glass plates, the brain substance had been subjected to pressure which was either too strong or too weak."]

The greater, therefore, is recognition due Fontana, who by obviously quite

("Ursprüngliche Nervencylinder"), "for it is these parts which make up the nerve, or its marrowy component" (p. 368). In his opinion the cylinders consist of *two* component parts: "The one is quite outside, rugged and irregular; the other is a cylinder, apparently formed from a particular, transparent skin, which is filled with a gelatinous humor of some consistency" (p. 370); cf. Fig. 6.

Fontana, therefore, distinguished in the nerve fibers between the cylinder which is composed of the *skin* and this skin's *contents*, and the encasing sheath which is composed of *serpentine* filaments (cf. Fig.

6 B). For this sheath he introduces the term serpentine cylinder (*geschlängelte Cylinder*). It is obvious from his drawing and description that he deals here with what is known today to be collagenous connective tissue.

Of the original cylinders, which were his own discovery, Fontana assumed that "they were the simple and primary organic elements of nerves" (p. 371).

The results of what he observed in the cortical and white substance of the brain, of which nothing had been known up to his time except the vessels,—the distinction between cortical and white substance in the brain being most probably attributable to Vesal—are of much less importance than what he has to say of the peripheral nerves. Thus he speaks of a gut-like (*darmähnlichen*) structure of white substance, which probably means that he imagined that he observed that the latter, on greater enlargement, "in reality appeared to be composed of an assembly of small, irregular bowels, sinuous, transparent, and filled with a gelatinous humor" (p. 373). These small bowels were of extreme shortness, and some of them terminated in globules. The structure of the cortex would thus not be essentially different from that of the white brain-substance. Because of its historical interest the corresponding drawing by Fontana is reproduced here together with the original wording (Fig. 7).

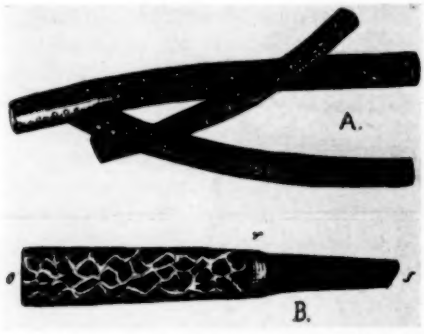


FIG. 6. ORIGINAL NERVE CYLINDERS. (B) REPRESENTING AN ORIGINAL NERVE CYLINDER, WITH *o-r* SHOWING THE THICKEST PART WHICH IS COVERED WITH A THIN FIBERED CELL-TISSUE; THE PART *r-s* BEARS NO SUCH CELL-TISSUE
After Fontana (4), Plate IV, Fig. 3 and Fig. 7.

It is remarkable that even the problem of the regeneration of peripheral nerves should have been drawn into the orbit of the research work instituted by Felice Fontana. He confirmed the experiments of Cruikshank who, according to Fontana (p. 350 *sqq.*), as early as 1778 and 1779, in experimenting on a dog bisected the eighth pair of spinal and intercostal nerves: these subsequently regenerated. Fontana realized by his own microscopical observations—and he even augmented them—that "not only do nerves unite again, if severed by a cut, but even if a piece of some length be excised. In the first instance, there ensues a true reunion of the parts, a true connection of the substance—in short an uninterrupted continuity of the original nerve cylinders and the skins which cover them. In the second instance, the nerve regenerates by itself; i.e. the nerve substance increases at both ends and by elongating, meet again, and form a homogeneous, connected and uniform whole" (p. 355).

No further progress can be recorded until the work of Gottfried Reinhold Treviranus (5) who, in an essay—published in 1816—*On the Organic Elements of the Animal Body*, confirmed the views of Fontana and also substantially supplemented them. Treviranus held that the nerve fibers were "skinny tubes which were filled with a tough matter, the myeline (*Nervenmark*) proper, and were held together in bundles by sheaths of cellular tissue" [cited, according to Henle (21), p. 776]. Contrary to Fontana, however, he found at the cylinders only *one* single skin, down the

interior surface of which there ran *serpentine channels*—which shows that Treviranus certainly did see the neurilemma, but misinterpreted what he saw.

Christian Gottfried Ehrenberg (6), of the *ganglion cells* in vertebrates and invertebrates: "In the ganglia of avian spinal nerves I have seen tubular nerves and very

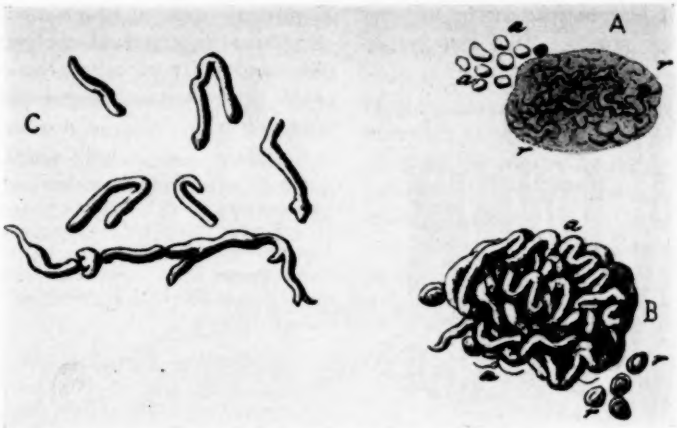


FIG. 7. FIGURE REPRESENTING THE WHITE BRAIN SUBSTANCE. (A) SHOWS A THIN PLANE OF THE WHITE BRAIN-SUBSTANCE WHICH, WHEN SEEN THROUGH MICROSCOPE, SEEMS TO CONSIST OF A HEAP OF SMALL INTESTINES *r*, *r*. (B) SHOWS THE SMALL INTESTINES AGAIN, WHEN OBSERVED THROUGH A MUCH STRONGER MICROSCOPE; *a*, *a*, THE SMALL INTESTINES; *r*, *r*, THE LITTLE GLOBULES. (C) SHOWS MANY IRREGULAR CORPUSCLES WHICH, WITH A NEEDLE, WERE DETACHED FROM THE WHITE SUBSTANCE SHOWN IN FIG. B.
After Fontana (4), Plate V, Fig. 7, 9, 16.

He established that there were no encasing sheaths in the nerve fibers of the brain and spinal cord, and he was the first to introduce the term *Nervenmark* (myeline) by which, however, he denoted the contents of the tubes. His report contained the first correct drawing—here reproduced as Fig. 8—of a myelinated nerve fiber from the sciatic nerve of the live frog.

"Since 1833, when the use of the microscope grew fairly common, renewed activity developed in the investigations on the nervous system. Although it may be said that, with the number of established facts, there also cropped up an increasing number of errors, these errors were instructive and recent years show some of the discoveries to be of lasting value." [J. Henle (21), p. 777.]

The year 1833 brought the discovery, by

FIG. 8. LAST NERVE-TUBE FROM THE SCIATIC NERVE OF A FROG
According to Treviranus (5), Plate XIV, Fig. 75. [Reproduced after L. Stieda (32).]

large, almost globular (*kugelförmige*), irregular bodies—some $\frac{1}{48}$ *Linien* in diameter—which formed the swellings proper and rather resemble some glandular substance" (6, p. 459). Ehrenberg was the first to

recognize in them structures of an individual character, and in a second report (7) described them as glandular globes (*drüsenartige Kugeln*), or club-like bodies (*keulenförmige Körper*). Of the true importance of his observations he had not the slightest notion. This may be inferred both from the names he proposed and from the curious way in which he compared his *globes* with the *small lime bags* found in fishes and from the fact that, on recapitulating his first report, he does not so much as mention the nerve cells!

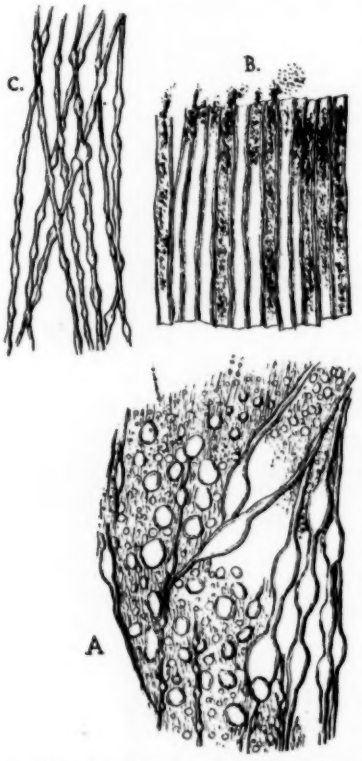


FIG. 9. HUMAN ARTICULATED BRAIN-TUBES. (A) SPINAL CORD SUBSTANCE, CONTAINING ARTICULATED TUBES OF EXTREMELY DIFFERING THICKNESS. (B) ARTICULATED BRAIN TUBES FROM THE OPTIC NERVE BEFORE THE CHIASMA. (C) ARTICULATED BRAIN TUBES FROM THE AUDITORY NERVE
After Ehrenberg (6), Plate VI, Fig. 3, 4, 6.

But Ehrenberg advanced another step in his study of the nerve fiber. He was one of the first to succeed in proving the existence of the central nerve fibers—he speaks of *articulate brain tubules* (*gegliederte Hirnröhren*)—and sharply distinguished them from the peripheral myelinated nerve fibers and what he called the *cylindrical simple nerve tubules* (*cylindrisch einfache Nervenröhren*).

In justice to historical truth it must be said that the central nerve fibers had been previously observed and recognized as such by Purkinje who—as Valentin (8) declared in 1834—"had, for some years past, been demonstrating them in his physiological lectures." Thus Valentin, when a student at Breslau in 1829 and 1830, had been shown these fibers (*Fäden*) by Purkinje.

According to Ehrenberg's description the brain fibers are "not simple cylindrical fibers, but, on the contrary, might be compared with pearl strings whose beads are not in contact, or they resemble vitreous tubules having bubbles. They are always straight, mostly parallel, but some times intersecting" . . . "very rarely split into two, otherwise invariably hollow." For this reason he called them intermittently swollen, i.e. varicose, articulate, tubules or channels ["*abwechselnd angeschwollene, das ist variköse, gegliederte Röhren oder Kanäle*" (6, p. 452)] (cf. Fig. 9).

An essential difference between the articulate brain tubules and the cylindrical, simple nerve tubules, i.e. between the central and peripheral nerve fibers, was found by Ehrenberg in that "the latter possessed a much larger inner cavity and therein encased very distinct, less transparent contents, which also had been recognized long ago" (6, p. 454).

Still further merit was acquired by Ehrenberg, when he showed beyond any doubt, the direct transition of the central into the peripheral, myelinated nerve fibers, and supplemented the proofs by a very good drawing (cf. Fig. 10).

According to his description, the nerves of the brain and the spinal cord, after emerging from the central organ, "gradually lose their varicose structure, the connecting parts of the globular or uniform joints grow thicker, and the whole finally takes on a cylindrical shape, of increasing regularity" (6, p. 459). He wrongly considered *none* but the peripheral nerve fiber to be myelinated; in his opinion, the same fiber in its central course "shows an entirely transparent, clear, marrowless, interior." Of the *Mark* (marrow, i.e. myeline) within the central nerve fibers he thought that it was a viscous, homogeneous juice.

This delusion, together with another erroneous assumption—which led him to believe that, apart from the central organ and the optic nerve, the olfactory and acoustic and the "middle course of the sympathetic" contained central nerve fibers—explains why Ehrenberg incorrectly classified the nerve fibers as *markloze* (marrowless, i.e. amyelinated) varicose tubules (of the brain, spinal cord and the three higher sensory nerves), and cylinder-shaped *markaltige* (marrowy, i.e. myelinated) tubules (of the peripheral nerves); to the sympathetic he ascribed both kinds of nerve fibers.

During the ensuing years hardly any attention was paid to Ehrenberg's first observation—entirely misconceived as to its importance—of the ganglion cells, which then usually were referred to as *Keulenkörper* (club-like bodies). The more violent the controversy around the question of the composition and importance of nerve fibers the more the principal interest of the discussion centered upon such problems as to how far these were to be considered artificial products, whether the nerve cylinders or nerve tubules were, in fact, hollow or solid structures, etc.

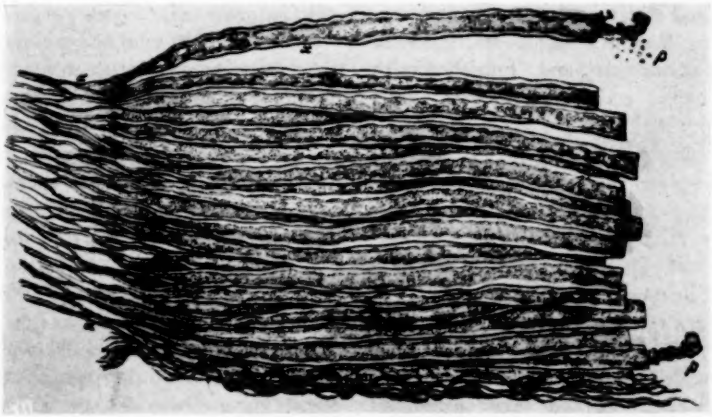


FIG. 10. A PIECE OF THE SCIATIC NERVE AT ITS ISSUE FROM THE SPINAL CORD. At α, THE TRANSITION OF THE ARTICULATED TUBES OF THE CORD TO THE CYLINDRIC TUBES OF THE SCIATIC. At ρ, NERVE MARROW EMERGING FROM THE TUBES
According to Ehrenberg (6), Fig. 11

Among such investigators as succeeded in demonstrating the existence of the ganglion cells, thus elucidating the nature of nerve fibers, the following names may be mentioned, according to the years in which they published their respective reports: Valentin, Remak, Purkinje, Volkmann, and Johannes Müller.

It was G. Valentin (9) who—as asserted by Kölliker (29, p. 546) in his *Microscopical Anatomy* published in 1850—rendered the first good description of the

nerve elements. To him the myelinated nerve fibers, from their extreme periphery to their entrance into the grey substance, were like many conduit-pipes which, according to their location, were composed of a sheath made up of cellular tissue of varying thickness, and evenly clear, transparent, semi-liquid contents; inserted between the varicose (i.e. central) and the peripheral section there were particular "intermediate fibers."

Valentin showed the wide diffusion of the ganglion cells throughout the brain, the spinal cord, the spinal and sympathetic ganglia, and distinguished between their different forms.

Already Valentin mentions "globules rounded at one side" and "furnished with a tail-shaped end at the other," discovered by Purkinje in the cortex cerebelli and since known by the name of Purkinje.

The whole of them Valentin calls either nucleated globules (*kernhaltige Kugeln*) or globular masses (*Kugelmassen*), or overlay-globules (*Belegkörper*), also overlay-masses (*Belegungsmassen*); the two latter expressions referring to their position *between* the nerve tubules. Within the ganglion cells he described the nucleus and the nucleolus and their occasional pigmentation, and he stressed his observation of their each having "an exterior, more or less distinctly cellular, covering." The location of the ganglion cells, as established by Valentin,—any connection between nerve cells and nerve fibers was entirely unknown at that time—also explains such expressions as were used by him—globules of the peripheral interstitial overlay-formation (*Kugeln der peripherischen interstitiellen Belegungsformation*) and globules of the pure, continuous overlay-formation (*Kugeln der reinen, kontinuierlichen Belegungsformation*)—to denote peripheral and central ganglion cells, respectively.

From the purely accidental fact that the first of those globules (*Kugeln*) were observed within ganglia, there originated the term ganglion or ganglionic globules (*Ganglienkugeln*), which I find to have been used for the first time in the *Jahresbericht über die Fortschritte der anatomisch-physiologischen Wissenschaften im Jahre 1836* (*Müllers Arch. f. Anat. Physiologie u. wissensch. Med., Jahrg. 1837*). Somewhat later, there appears the standard expression ganglion cell (*Ganglienzelle*)—now still used—and which, to quote an instance, is employed by A. Hannover (19, p. 556) to distinguish between this cell and the brain cell (*Hirnzelle*).

Robert Remak, who wrote a number of neuro-histological works, in his first publication (10) in 1836 described and illustrated those strictures which afterwards by the name of "Lanterman's Incisors" were to find their way into the literature of the subject.

Particular mention must be made here of this publication (10) on account of its being the first to deal with the *development of nerve fibers*. According to Remak's report the myeline-sheathed fibers contained no medulla at first, and passed into cylindrical form through the intermediate stage of transitional fibers. He had noticed moreover that the formation of myeline in the nerves of young pigeons advanced at a quicker rate of progress than in rabbits of corresponding age.

In his next publication Remak (11) reported on the discovery of the *axis cylinder*. While many of the earlier authors, as Ehrenberg for instance, had considered the primitive fibers or primitive tubes to be hollow structures, and Purkinje had his doubts about this view, Remak found in these cylinders a smooth, glossy filament, often protruding from the interior of the tube, which was of tougher texture than the sheath, and which he called the

primitive band (*Primitivband*). On being variously magnified and illuminated, this primitive band very often "impressed him as being composed of very minute, solid fibers, which, in their course, sometimes swelled out into small nodules." For this reason Remak believed, not incorrectly, that "the primitive band one day would prove to be a primitive bundle."

Remak (25, p. 197) in an essay—published in 1843—on the nerves found in the ventral cord of *Astacus fluviatilis*, calls the axis cylinder the central bundle of nerve fibers (*das centrale Nervenfaserbündel*), because "it is composed of extremely tender fibers, which, within the tube, occupy a fourth to a third part of its diameter."

In 1837, Johann Evangelista Purkinje (13) stated in his "Latest researches into the anatomy of the nerves and the brain" —a paper read at the Naturalists' Congress held in Prague—that in a "very minute, transparent cross-section of the nerve-bundles of a freshly removed nerve . . . there appeared at the extreme periphery a circular double-contour, corresponding to the encasing membrane of the nerve cylinder, which, like a vessel, contains the myeline; thereupon follows towards the center a thicker circle, the stratum of the myeline, and in the center a multi-cornered, entirely transparent spot, which might be regarded as the interior channel of the myeline" (p. 177). (Cf. Fig. 11.)

"On inspection of a thin longitudinal section of the hardened nerve, the center of the medulla displayed a minute, transparent streak. A similar phenomenon was observed in the cylindrical fibers, when they were squeezed from out of their hose-like elementary filament" (p. 177 to 178). Purkinje thought that "those observations pointed to some organically planned structure within the medulla of the elementary nerve cylinder, and that it was difficult to believe of such structural relations that they should have been caused alone by the effect of the hardening agents" (p. 178).

The expression *cylinder axis* (Latin: *cylinder axis;* German: *Achsencylinder*), meant to denote the central fiber which was discovered by Remak—although also observed nearly simultaneously by Purkinje—appeared for the first time in the dissertation "De formatione granulosa in nervis aliisque partibus organismi animalis" published in 1839 by J. F. Rosenthal [17, p. 16—quoted from J. Henle (21, p. 782)], a pupil of Purkinje's. It seems that Rosenthal was also the first to use the term *myeline sheath* (*vagina medullaris, Markscheide*).

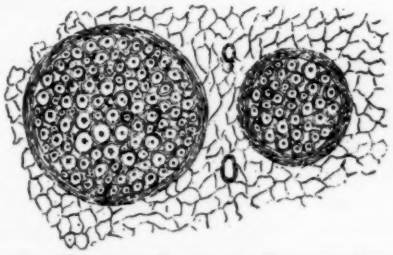


FIG. 11. TRANSVERSE SECTION OF A HARDENED NERVE After Purkinje (13) Fig. 9.

Concerning the ganglion cells, Purkinje had, as early as 1831, conceived a fairly adequate notion of the structure of nerve cells. In that year, on observing the so-called substantia nigra (cf. Fig. 12, A), he detected "dark-brown spots (*Flocken*), even fairly visible to the unaided eye," and he realized at once their complete analogy to those ganglionic granules, afterwards discovered by Ehrenberg. Purkinje then studied ganglion cells from widely different parts of the central organ: e.g., of the cerebral and cerebellar cortex (cf. Fig. 12 B), of the corpus geniculatum, cornu ammonis, optic thalamus, substantia nigra, the pons and the olivae. He summarized the essential characteris-

tics of the ganglion cell—which he usually denoted as ganglionic corpuscles (*Ganglióse Körperchen*)—in a manner which, judged by the standards of his age, was nothing short of remarkable: "A granular, partly globular, partly round-edged shape, with or without one or more processes; their substance is fairly hard, transparent, consisting of a mass of free, probably nervous, points, and to the pressure of chemical reagents offers more encellular or even fibroid covers, out of which it is impossible to remove them otherwise than by the strongest pressure; covers of this kind are not observed in the ganglionic corpuscles of the brain; in many ganglionic granules of the cerebral and the nervous system there are found pigmented spots. . . ." (p. 179).

As to the meaning of the ganglion cells, Purkinje stated that "they probably were central structures, which was suggested

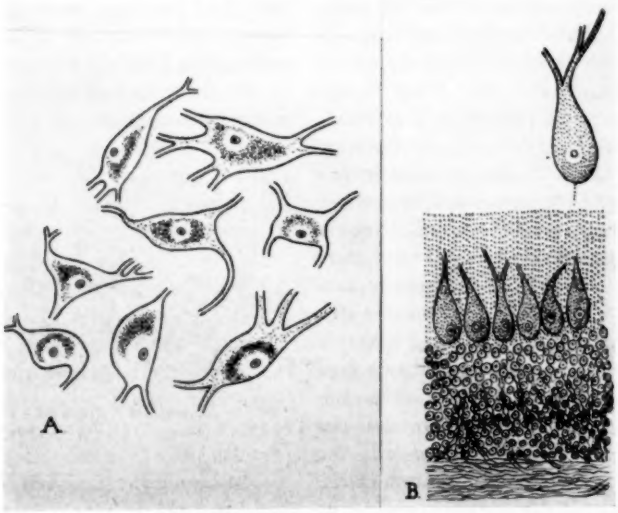


FIG. 12. (A) MULTIPOLAR GANGLION CELLS FROM SUBSTANTIA NIGRA, SHOWING PIGMENT. (B) FIRST DRAWING REPRESENTING THE PURKINJE CELLS IN THE CEREBELLUM
According to Purkinje (13), Fig. 16 and 17

during resistance than any other nerve substance; the ganglion cell, which measures from $\frac{8-30}{800}$ of a Viennese 'Linie', must be called large, if compared with other microscopic structures. Within, it contains a round, slightly pellucid nucleus, which again is encased in a larger spherical covering, and in size is proportionate to the size of the ganglionic granule as a whole; such granules as are situated within the nerve ganglia possess individual

by the whole of their thrice concentric organization, and the relation they might bear to the elementary cerebral and nerve fibers probably resembled that between force-centers and conducting-lines, or ganglia and ganglionic nerves, or cerebral masses with spinal nerves and the brain. They might be collectors, generators, and distributors of the nervous organ" (p. 180).

Apart from these considerations, Purkinje had already considered the ques-

tion "of the relation between the ganglionic corpuscles and the elementary fibers of the nerves and brain," of which, however, "it had been found impossible so far," according to his statement, "to ascertain anything of a definite character" (p. 179).

Meanwhile, in 1837, Remak (12) had inserted the last link in the chain of such discoveries as were made previously to the appearance of Schwann's treatise. He succeeded in proving that the grey color, observed in the sympathetic cord, was not caused "by the ganglionic globules there scattered, but by fibers themselves." These, accordingly, differed from the already known white nerve fibers by their peculiar structure and, in Remak's opinion, originated within the sympathetic ganglion cells. In subsequent remarks (14, 15) he spoke of them as the *grey fibers*, or *organic nerve fibers*. They have ever since been known by his name: *Remak fibers*.

Publication No. 15 is merely an extract from Remak's extensive and well-known dissertion "Observationes anatom...ae et microscopicae de systematis nervosi structura" of 1838, a copy of which has been at my disposal in the original and from which Fig. 13 is reproduced. The other publications of Remak (Nos. 11, 12 and 15 of the bibliography) had to be cited according to the sources mentioned.

With Remak (14, p. 5) the passage in question runs: [It should be borne in mind that the fibers of the grey cords] "are not tubular, i.e. surrounded with a sheath, but naked, being transparent, almost gelatinous, and much more minute than most of the primitive tubes. They almost always exhibit longitudinal lines upon their surface and readily separate into very minute fibers. In their course they are very frequently furnished with oval nodules and covered with certain small oval or round, more rarely irregular, corpuscles, which exhibit one or more nuclei, in size almost equal to the nuclei of the ganglion globules." This passage, together with the drawing supplementing it (cf. Fig. 13), clearly shows that Remak was quite an acute observer of the nerve fibers he discovered.

But, in my opinion, particular importance ought to be ascribed to the fact that Remak realized how the organic nerve fibers originate from the ganglionic globules of the sympathetic ganglia (cf. Fig. 13)—while he saw a peculiar difference "between the sympathetic and the spinal ganglia in that within the spinal ganglia the fibers pass between the ganglionic globules, or weave their fabric around the latter." To continue in his own words: "The organic fibers (of the *sympathetic* ganglia) originate from the substance of the nucleated globules. They are visible as cords of varying strength, sometimes resembling the primitive tubes, very transparent, but differing inasmuch as they are composed of the *most minute, non-tubular* fibers; or there issue forth from several points of the globes the most minute fibers, which, right from their origin are knotty, and *quite distinctly pass into organic fibers*."

We might still mention that Volkmann (16), when studying frog ganglia, came across those globules, discovered by Ehrenberg; but he doubted whether the "extremely regular, almost quite globular, rarely oval" structures represented any part of the nervous tissue at all.

IV

In rough outline we have here sketched the stage of development of neuro-histological research as it was at the time of the publication of Schwann's work which was to make his name forever famous.

Lack of space prevents quotation from works from authors who failed to reach results of a general nature. But it would

be wrong to imagine the previous development as having proceeded along more or less straightforward lines. On the contrary, each one of the fundamental discoveries gave rise to disputes which we need not enter into here. For instance, Arnemann, in 1787—as related by Stieda (32, p. 11)—declared Fontana's discovery to be an "optical illusion." Even at and after Schwann's time, nearly all the histological observations here referred to met with much opposition, a fact that only serves to add to our esteem for Schwann's achievement. No mention has been made of some theories which today appear very odd: e.g., Ehrenberg maintained that the peripheral nerve fibers were motor and regarded the central ones as nerves of sensation.

Thanks to the discovery of the *myelinated nerve fibers in the peripheral and central nervous system*, of the *grey fibers* and *the ganglion cells*, the principal elements of which the nerve texture is composed had become known. But the architectural organization of the structure into which these elements enter remained shrouded in darkness as it had been before.

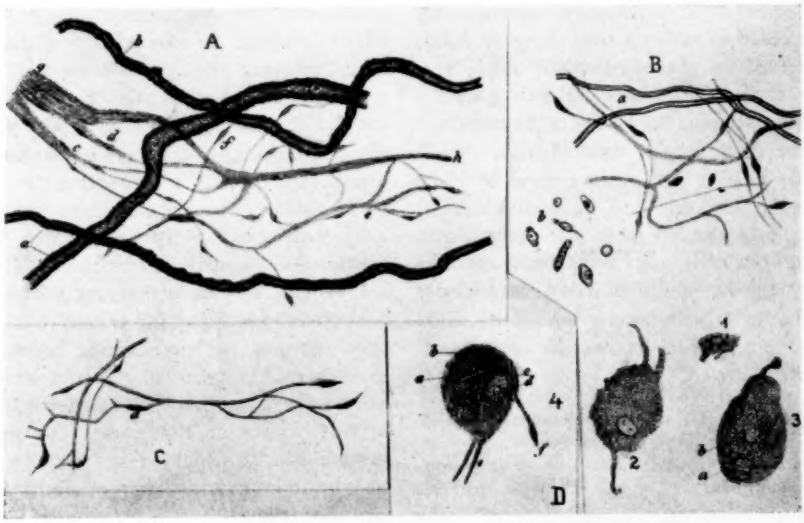


FIG. 13. (A, B) NERVE FIBERS FROM THE BOVINE SYMPATHETIC (200× MAGNIFIED). (A) *a*, *b*, AND (B) *a*, PRIMITIVE TUBES. (A) *c-b*, ORGANIC NERVE FIBERS, AT (B) *b*, SOME NUCLEATED CORPUSCLES ISOLATED FROM THE COURSE OF THE ORGANIC FIBERS. (C) ORGANIC NERVE FIBERS FROM THE HUMAN SYMPATHETIC (150× MAGNIFIED), AT *a*, ONE NUCLEATED CORPUSCLE. (D) GANGLIONIC GLOBULES FROM A BOVINE SYMPATHETIC GANGLION WITH ORIGINATING ORGANIC NERVE FIBERS, AT *3*, ONE BINUCLEATED GANGLION CELL (*1* = 75× MAGNIFIED, *2* AND *3* = 200× MAGNIFIED, *4* = 150× MAGNIFIED)
According to Remak (14), Fig. 2, 3, 4, 7, 9

The merit of Theodor Schwann consists in his having been able to prove the *cellular nature* of the ganglion globules. The former names, as e.g., club-like bodies (*Keulenkörper*) or overlay-globules (*Belegungskugeln*), given to them by Ehrenberg and Valentin, respectively, are sufficient to prove that no one had the slightest notion of their true nature.

Schwann's accomplishment was to form the permanent foundation on which the

impressive edifice of neuro-histological science could be erected. Founded on that base are also the further discoveries of which I shall point out the most important: the real relation existing between nerve cell and nerve fiber (cf. Fig. 14). A connection between ganglion cell and nerve fiber had been first asserted by Remak for the sympathetic nervous system, and as early as 1840 described by Hannover (19); in 1842 it was definitely proved for invertebrates—mostly on the brain ganglia of *Hirudo vulgaris*—by Helmholtz (22), and in 1844 for vertebrates by Kölliker (26).

It is odd, indeed, that in 1841 J. Henle (21) and, even as late as 1850, A. Kölliker (29) should declare themselves to have been unsuccessful in their endeavor to observe these nuclei. Also Bidder (27) in his celebrated treatise *Zur Lehre von dem Verhältniss der Ganglienkörper zu den Nervenfasern* (cf. Fig. 14), does not so much as mention the cells of Schwann. Bidder obviously failed to notice the nuclei of Schwann, although in the bipolar ganglion cells from the cerebral ganglia of *Esox lucius* he had an excellent object (cf. Fig. 14) for observation—by means of which, on the other hand, he found sure and convincing proof of the direct transition of the neurilemma from nerve fiber to ganglion cell.

As far as I have been able to ascertain, E. Reissner (30) was the first (1861) to form a correct notion of the regular occur-

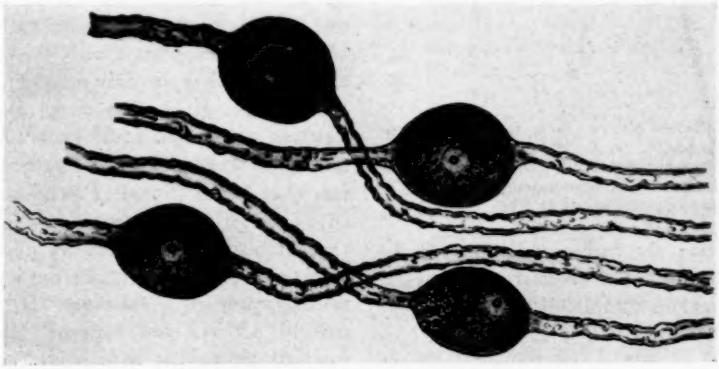


FIG. 14. GANGLIONIC GLOBULES INSERTED INTO ENLARGED PARTS OF WIDE PRIMITIVE TUBES From the trigeminus of *Esox lucius*. Immediate transition of the "primitive sheath" from nerve fibers to the ganglion cell. According to Bidder (27), Plate I. [Detail from Bidder, Fig. I.]

The existence, within the nerve fibers, of the *cells of Schwann*, was soon confirmed by numerous authors; the first among these were J. F. Rosenthal [17, p. 18, cited from J. Henle (21), p. 620)] and Johann N. Czermak (28), both of whom had been disciples of Purkinje, G. Valentin (20), R. Remak (25), and E. Reissner (30).

Valentin's confirmation of Schwann's discovery concerns the development of the nerve fiber where he had observed the plentiful occurrence of the nuclei. Further remarks on this point will be found in my forthcoming monograph.

rence of the Schwann cells: he showed how to stain with carmine their spindle-shaped or elongated nuclei after having hardened the nerve in chromic acid. He found that these nuclei were rather sparsely diffused throughout the thick fibers, while more plentiful in the minute ones (cf. Fig. 15), "but they were always present in any piece of an isolated nerve above a certain length" (p. 730). That is why Reissner "from numerous observations on the nerves of man and of some vertebrates" draws the correct conclusion that the

nuclei, which had been "previously observed in the primitive sheaths of nerve fibers by Schwann" would have to be "considered to represent a universal characteristic of the nerve fibers in general." "By proving the regular occurrence of nuclei within the primitive sheaths of

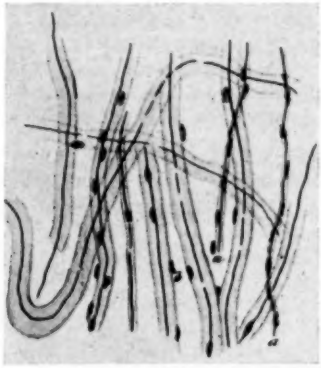


FIG. 15. ISOLATED NERVE FIBERS FROM THE HUMAN OCCULOMOTORIUS. *a*, *a*, MINUTE NERVE FIBERS WITH NUMEROUS NUCLEI; *b*, ONE NUCLEUS PARTLY DETACHED FROM THE NEURILEMMA
After Reissner (30), Plate XVII, Fig. 5

nerve fibers, the correspondence with the sarcolemma of the cross-striated muscle fibers becomes complete" (p. 731).

Theodor Schwann's contribution to the development of neuro-histology consists of:

(a) his realization of the cellular character of the ganglion cells;

(b) his discovery of the cells since known by his name—although, in justice to historical truth, it must be mentioned that prior to him Robert Remak had seen analogous nuclei in those grey or organic fibers of which he gave the first description;

(c) the establishment of the so-called cell-chain theory in the development of the peripheral nerve fibers.

This paper—occasioned by the centenary of Schwann's famous treatise—represents an extract from the introductory chapter of a monograph on the *Cell of Schwann*, the publication of which has been delayed. We now usually refer to the sheath cells of Schwann or sheath cells, which is in accordance with the German expression *Zellen der Schwannschen Scheide*. But I doubt if by this term *sheath* the function of the cell could be adequately, much less exhaustively, characterized—a fact that I (34) hinted at years ago, and that I am going to revert to more fully in the forthcoming publication. But even so, at this juncture, I prefer the less committing term *cell of Schwann*. This proposition perhaps will appear the more justified, because it then would not give rise to misunderstanding—the name of Schwann being commonly used only with this *particular* kind of cell.

LITERATURE CITED

1. SCHWANN, TH. 1839. Mikroskopische Untersuchungen über die Uebereinstimmung in der Struktur und dem Wachstum der Tiere und Pflanzen. Sander'sche Buchhandlung (G. E. Reimer). *Berlin*. Translated from the German by HENRY SMITH: "Microscopical Researches into the Accordance in the Structure and Growth of Animals and Plants." Printed for the Sydenham Society, *London*, 1847.
2. DELLA TORRE. 1776. Nuove Osservazioni mikroskopiche. *Napoli*. Cited according to Fontana (4, b), p. 358.
3. PROCHASKA, GEORG. 1779. Tractatus de Structura Nervorum. Vindobona. Cited according to Fontana (4, b), p. 358.
4. FONTANA, FELIX. (a) 1781. Traité sur le Vénin de la Vipère, sur les Poisons americains . . . Sur la Structure primitive du Corps animal. Tome premier et tome second. *Florence*.

   (b) 1787. Abhandlung über das Viperngift, die amerikanischen Gifte, das Kirschlorbeergift und einige andere Pflanzengifte, nebst einigen Beobachtungen über den ursprünglichen Bau des tierischen Körpers, über die Wiedererzeugung der Nerven und der Beschreibung eines neuen Augenkanals. Erster und zweiter Band. Aus dem Französischen übersetzt. *Berlin*.

5. Treviranus, G. R. und L. C. 1816. Vermischte Schriften anatomischen und physiologischen Inhalts. Bd. I. p. 128. *Göttingen.* Cited according to Henle (21) p. 776 and Stieda (32).

6. Ehrenberg, C. G. 1833. Notwendigkeit einer feineren mechanischen Zerlegung des Gehirns und der Nerven vor der chemischen, dargestellt an Beobachtungen von C. G. Ehrenberg. *Poggendorfs Annalen der Physik und Chemie.* Bd. 28, p. 448.

7. Ehrenberg, C. G. 1834. Beobachtung einer auffallenden bisher unerkannten Struktur des Seelenorgans bei Menschen und Tieren. Abhandl. d. K. Akad. d. Wiss. zu Berlin aus d. J. 1834, *Berlin*, 1836, p. 605.

8. Valentin, G. 1834. Ueber die Dicke der varikösen Fäden in dem Gehirne und dem Rückenmarke des Menschen. *Müllers Arch. f. Anat., Physiologie u. wissenschaftliche Medicin*, p. 401.

9. Valentin, G. 1836. Ueber den Verlauf und die letzten Enden der Nerven. *Nova Acta Academ. Caes. Leopold.-Carol. nat. cur.* Bd, 18, p. 1 and 51.

10. Remak, Robert. 1836. Vorläufige Mitteilung microscopischer Beobachtungen über den inneren Bau der Cerebrospinalnerven und über die Entwickelung ihrer Formelemente. *Müllers Arch. f. Anat., Physiologie u. wissenschaftliche Medicin*, p. 145.

11. Remak, Robert. 1837. Weitere microscopische Beobachtungen über Primitivfasern des Nervensystems der Wirbeltiere. *Froriep's Neue Notizen*, Bd. 3, p. 35. Cited according to Stieda (32).

12. Remak, Robert. 1837. Neurologische Notizen. *Ibid.*, Bd. 3. p. 150. Cited according to Stieda (32).

13. Purkinje, J. E. 1837. Neueste Untersuchungen aus der Nerven- und Hirnanatomie. Bericht über die Versammlung deutscher Naturforscher und Aerzte in Prag im Jahre 1837. *Prag*, p. 177, 1838.

14. Remak, Robertus. 1838. Observationes anatomicae et microscopicae de Systematis nervosi Structura. Sumptibus et Formis Reimerianis, *Berolini.*

15. Remak, Robert. 1838. Ueber die Struktur des Nervensystems. *Froriep's Neue Notizen*, Bd. 6, p. 342. Cited according to Stieda (32).

16. Volkmann, A. W. 1838. Ueber die Faserung des Rückenmarkes und der sympathischen Nerven in *Rana esculenta. Müllers Arch. f. Anat., Physiologie u. wissenschaftliche Medicin*, p. 274.

17. Rosenthal, Joseph. Ferd. 1839. De Formatione granulosa in Nervis aliisque Partibus Organismi Animalis. Diss. inaug. anat.-physiol. *Vratislaviae.*

18. Valentin, G. 1839. Ueber die Scheiden der Ganglienkugeln und deren Fortsetzungen. *Müllers Arch. f. Anat., Physiologie u. wissenschaftliche Medicin*, Jahrg. 1839, p. 139.

19. Hannover, Adolf. 1840. Die Chromsäure, ein vorzügliches Mittel bei mikroskopischen Untersuchungen. *Ibid.*, Jahrg. 1840, p. 549.

20. Valentin, G. 1840. Zur Entwickelung der Gewebe des Muskel-, des Blutgefäss-und des Nervensystems. *Ibid.*, Jahrg. 1840, p. 194.

21. Henle, J. 1841. Allgemeine Anatomie. Lehre von den Mischunga-und Formbestandteilen des menschlichen Körpers. L. Voss, *Leipzig.*

22. Helmholtz, H. 1842. De Fabrica Systematis nervosi Evertebrarum. Diss. inaug. *Berolini.* Cited according to the report by K. B. Reichert in *Müllers Arch. f. Anat., Physiologie u. wissenschaftliche Medicin*, Jahrg. 1843.

23. Valentin, G. 1842. Gewebe des menschlichen u. tierischen Körpers. *In* R. Wagner's Handwörterbuch der Physiologie, Bd. I. p. 617, Vieweg u. Sohn, *Braunschweig.*

24. Remak, Robert. 1843. Ueber den Inhalt der Nervenprimitivröhren. *Müllers Arch. f. Anat., Physiologie ul wissenschaftliche Medicin*, p. 197.

25. Hannover, Adolf. 1842. Mikroskopiske Undersögelser af Nervesystemet Kjöbenhavn.—French translation: "Recherches microscopiques sur le Système nerveux," *Copenhague, Paris* et *Leipzig*, 1844.

26. Kölliker, A. 1844. Selbsständigkeit und Abhängigkeit des sympathischen Nervensystems durch anatomische Beobachtungen bewiesen. Meyer u. Zeller, *Zürich.* Especially p. 22.

27. Bidder, F. H. 1847. Zur Lehre von dem Verhältniss der Ganglienkörper zu den Nervenfasern. Nebst einem Anhange von A. W. Volkmann. Breitkopf und Härtel, *Leipzig.*

28. Czermak, Johann, N. 1849. Ueber die Hautnerven des Frosches. *Müllers Arch. f. Anat., Physiologie u. wissenschaftliche Medicin*, p. 252.

29. Kölliker, A. 1850. Mikroskopische Anatomie oder Gewebelehre des Menschen. 2. Bd. W. Engelmann, *Leipzig.*

30. Reissner, E. 1861. Neurologische Studien. *Arch. f. Anat., Physiologie u. wissenschaftliche Medicin*, p. 615 and 721.

31. Henle, J. 1882. Theodor Schwann. *Arch. f. mikr. Anat.*, Bd. 21, p. 1–49.

32. Stieda, Ludwig. 1899. Geschichte der Entwickelung der Lehre von den Nervenzellen und Nervenfasern während des XIX. Jahrhunderts. Festschrift zum 70. Geburtstag von Carl von Kupffer. Gustav Fischer, *Jena.*

33. Sudhoff, Karl. 1910. Theodor Schwann. *Münch. med. Wschr.*, Jahrg. 57, 2703–2705.

34. Münzer, Franz Th. 1931. Ueber markhaltige Ganglienzellen. *Z. mikr.-anat. Forsch.*, Bd. 24, p. 286–362.

HOMING INSTINCT IN SALMON

By BRADLEY T. SCHEER

The Scripps Institution of Oceanography (Contribution No. 73)

KNOWLEDGE of the migrations of fishes is of considerable economic importance and biological interest. Most fisheries depend on the congregation of certain species for feeding or spawning in definite regions; a knowledge of the movements of the fishes to and from these regions has aided the prosecution of the fishing operations and has been of value in attempts at regulation of these operations with a view to conservation. Russell (1937) states that most fish migrations consist (1) of a dispersal of eggs, larvae, or young fishes by passive drifting with the current or by active seeking of the normal habitat, then (2) of an active movement, usually against the current, to the spawning grounds, and finally (3) of a dispersal of the spent fishes, either by movement with a current or an active feeding migration.

Salmon migrations are in general accord with this plan. The young fishes go down-stream to the sea after a stay in fresh water which varies in length with the species and with conditions in the stream. There follows a period of feeding and growth in the sea which also varies in length, but rarely, if ever, exceeds five or six years. The mature fishes now enter streams and proceed to spawning grounds; after spawning, the Pacific species of salmon die, while the steelhead trout and the Atlantic salmon may return to the sea, subsequently to enter a stream and spawn again.

The suggestion was made many years ago that the salmon invariably returns for spawning to the stream in which it was hatched. Many biologists looked upon this view with skepticism. Jordan (1925) opposed the idea, and Rutter (1903) said,

> "It is incredible that the salmon remember their native stream during two or three years of ocean life and that they consciously seek it when they desire to return to fresh water. Probably most of them do return to the stream from which they entered the ocean, not because it is their native stream, but because they do not get very far from its mouth, and when ready to return to fresh water, it is the first to attract them."

This belief has been maintained up to the present time by certain workers (Huntsman, 1937a,b, 1938a,b,c,d, 1939; Ward, 1939a,b). Others, however, have become convinced that salmon may go considerable distances in the sea, and yet return in a great majority of cases to their parent stream (Calderwood, 1908, 1931, 1937; Clemens, Foerster, and Pritchard, 1939; Davidson, 1937; Menzies, 1938b; Pacific Fisherman, 1937; Rich, 1937a,b, 1939; Shapovalov, 1939). This paper is an attempt at an impartial evaluation of such information bearing on the question of "homing" as is available in the literature.

There are several common names in use for the seven species of salmon and trout on which the studies reported here were made. Specific names, to avoid confusion, will be used here. The corre-

sponding common names are given in the table.

METHODS

In large part, data on salmon migrations have been accumulated by means of marking and tagging experiments. Young fishes have been marked by the removal of one or more fins; adult fishes have been tagged by affixing a numbered tag of metal or other material to the caudal fin. The only errors inherent in the tagging method appear to be the possibility of loss of the tag, or of an increased mortality of tagged fishes. This method cannot be applied to young fishes, however, so that most experiments on Pacific salmon have involved fin mutilation. It has frequently been demonstrated that removal of a single fin or even of two members of the same pair of fins does not give reliable results. Marsh and Cobb (1911) reported results from 1600 specimens of *O. nerka* marked in the Naha River, Alaska, by removal of both ventral fins. Nearly half of the recoveries were made in another river, so the search was continued for several years. Finally, Cobb (1917) concluded "... This experiment proves ... that the percentage of salmon which accidentally lose ... one or more fins is much larger than most people suppose." Similar experiences have been noted by other workers, and it is now the belief of most that to obtain valid results in fin-marking, it is necessary to remove two fins, one from each of two regions—as, for example, the adipose fin and one of the ventrals. It has also been found that the fin rays must be removed completely in order to preclude the possibility of regeneration. These matters are discussed by Rich and Holmes (1928) and by Pritchard (1927).

Two general types of experiment have been performed. Young fishes have been marked in streams at the time of liberation from a hatchery or at the time of the down-stream migration. These fishes have subsequently been recovered in this same stream, at sea, or occasionally in other streams. Adult fishes have been tagged in the sea, and recovered later elsewhere at sea or in streams. In addition, profiting from the fact that *S. salar* makes several spawning migrations, Atlantic Coast workers have tagged adult specimens in streams after spawning (kelts). In interpreting results from marking and tagging experiments, it must be remembered that results will depend on several factors other than the actual number of fishes in a given area. Of first importance is the intensity of fishing operations in the area. In second place, is the possibility that marked or tagged

TABLE 1

Common names of salmon and trout

GENUS	SPECIES	COMMON NAME
Oncorhynchus	sp.	Pacific salmon
	gorbuscha	Humpback or pink salmon
	keta	Chum or dog salmon
	kisutch	Coho or silver salmon
	nerka	Blueback, quinault, red, or sockeye salmon
	tschawytscha	Chinook, king, quinnat, spring, or tyee salmon
Salmo	*gairdnerii*	Steelhead trout
	salar	Atlantic salmon

fishes may not be observed or reported. In general, rewards are offered for the recovery of such fishes, and in many cases, trained observers are stationed at canneries, counting wiers, and other places where large numbers of fishes are easily seen.

THE MARKING OF SALMON IN STREAMS

The results of all of the experiments which the writer has been able to discover in the literature in which salmon have been marked or tagged in streams are summarized in Table 2. Certain experiments in this group can at once be eliminated as invalid. Thus, experiments 6 and 25 involved the removal of the adipose fin only; this mark is very often duplicated in nature. Experiments 15, 17, 18, 26, and 28 involved the removal of both pectoral or both ventral (pelvic) fins: Cobb (1917) has shown that this mark may also lead to erroneous results. Of the experiments remaining, we must use great care in evaluating those reported by Huntsman (1938a: expts. 7–13) since the tags were affixed to fishes caught in the estuaries of the various streams, with the exception of the Annapolis (expt. 8). It is known that mature fishes may enter the estuaries of rivers, leave these estuaries without proceeding up the rivers, and later enter other rivers to spawn. Taft and Shapovalov (1938) report an experience with *S. gairdnerii* in two small California creeks. The fish in question was marked by removal of adipose and left ventral fins at the hatchery, two miles upstream from the mouth of Scott Creek, in February, 1935. In February of 1937, it appeared at a counting wier situated a mile from the mouth of Waddell Creek, a stream which enters the Pacific Ocean five miles north of the mouth of Scott Creek. The fish was taken from the water, further marked by removal of half of the dorsal fin, and scales and measurements taken; it was then replaced in the stream. Five days later, the same fish, easily recognizable and still unspawned, was found at the Scott Creek hatchery. An experience with *O. tschawytscha* in the Columbia River is also of interest here (Higgins, 1937). Over 1,000 adult fishes from the fall spawning run in the Columbia were tagged at a point nearly five miles up the river (i.e. in the estuary); five of these were soon afterwards taken in the sea outside the river, and one entered a small river several miles north of the Columbia. It cannot then be stated with any degree of positiveness that all fishes to be found in the estuaries or near the mouths of rivers would normally spawn in those same rivers.

Bearing these considerations in mind, we may now turn to Table 2. The accuracy of the homing of *O. nerka* to the Fraser River is beyond question. (Clemens, Foerster, and Pritchard, 1939: expt. 19) when it is considered that nearly 2500 fishes were recovered in Cultus Lake, where they had been marked, and that none appeared in any other river system than the Fraser. Furthermore, the other 8400 recoveries were all made in areas which would conceivably be en route from the sea to the Fraser, at the time of the normal spawning run through these areas. Impressive likewise are the results of Snyder (1931: expt. 21) in the Klamath with *O. tschawytscha*, and of Rich and Homes (1928: expt. 20) with the same species in the Columbia. These and the other experiments leave but little doubt that in many cases the return to the stream of liberation is overwhelming.

There are, however, a few cases, other than those which might be ascribed to faulty marking, in which a notable amount of straying has taken place. Taft and Shapovalov (1938: expt. 29) report that 35 specimens of *O. kisutch*

EXPT. NO.	GENUS	SPECIES	AUTHOR	DATE	RIVER	REGION	MARK USED	NUMBER MARKED	NUMBER RECOVERED IN			
									Stream of liberation	General vicinity	Elsewhere at sea	Other streams
1	*Salmo*	*salar*	Calderwood	1903–8	Deveron	Scotland	Tag	—	4	5	7	0
2	"	"	"	"	Helmsdale	"	"	—	24	1	7	1
3	"	"	"	"	Naver	"	"	—	16	1	1	0
4	"	"	"	"	Tay	"	"	—	49	1	0	0
5	"	"	Alm	1931	Indals & Angermann	Sweden	"	6,325	12	0	10	0
6	"	"	White	1936	Apple	Nova Scotia	Ad	3,252	92	0	0	6
7	"	"	Huntsman	1938	Apple	" "	Tag	235	17	1	1	0
8	"	"	Rodd	1934–38	Annapolis	" "	"	734	17	2	10	0
9	"	"	"	"	Margaree	" "	"	3,534	25	67	13	1
10	"	"	"	"	Miramichi	New Brunswick	"	2,104	23	0	2	0
11	"	"	"	"	Restigouche	" "	"	1,990	26	0	1	1
12	"	"	"	"	Sackville	Nova Scotia	"	398	19	0	4	0
13	"	"	"	"	St. John	New Brunswick	"	2,021	35	2	0	0
14	"	*gairdneri*	Taft & Shapovalov	1938	Waddell	California	Ad V	4,479	203	0	0	2
15	"	"	" " "	"	"	"	P P	3,118	27	0	0	3
16	"	"	" " "	"	Scott	"	Ad V	17,683	432	0	0	6
17	"	"	" " "	"	"	"	V V	26,713	127	0	0	1
18	*Oncorhynchus*	*nerka*	Marsh & Cobb	1911	Naha	Alaska	V V	1,600	21	0	0	19
19	"	"	Clemens, Foerster, & Pritchard	1939	Fraser	Br. Columbia	Ad PP	469,326	2,492	8,404	0	0
20	"	*tschawytscha*	Rich & Holmes	1928	Columbia	Oregon-Wash.	Ad V Ad D / DV Ad VV	334,000	498	3	1	0
21	"	"	Snyder	1931	Klamath	California	Ad V	122,000	1,171	32	150	0
22	"	"	"	"	Sacramento	"	Ad V	48,400	22	4	0	0
23	"	*gorbuscha*	Davidson	1934	Duckabush	Washington	Ad D	36,000	8	0	0	2
24	"	"	"	"	Snake	Alaska	Ad D	50,000	23	0	0	0
25	"	"	Pritchard	1939	McClinton	Br. Columbia	Ad	185,557	96	36	52	0
26	"	"	"	"	"	" "	VV	107,949	2,941	325	10	0
27	"	"	"	"	"	" "	Ad VV	85,634	35	0	0	0
28	"	"	"	"	"	" "	Ad V	108,200	4	0	34	6
29	"	"	"	"	Fraser	" "	VV	8,741	5	51	2	6
30	"	*kisutch*	Taft & Shapovalov	1938	Waddell	California	Ad V	6,683	140	0	1	35

Note: The term "general vicinity" applies to the area in the sea along the coastline between the stream in which the marking was done and the next stream of comparable size. Abbreviations: Ad = adipose fin, V = ventral fin, P = pectoral fin, D = dorsal fin.

strayed from Waddell Creek, where they were marked, to Scott Creek, five miles away. In the same period, 140 fishes from the same marking appeared in Waddell Creek. In this experiment, every fish passing up both streams was examined. The fishes marked were from naturally spawned eggs. Another case of straying is shown in expt. 28 (Pritchard 1938, 1939) where six specimens of *O. gorbuscha* reared and marked at McClinton Creek (in the Queen Charlotte Islands area, B.C.) from eggs from the nearby Tlell River, were found in the Fraser River, over 500 miles to the south and east. Thirty-four other specimens from this marking were found in the Gulf of Georgia, near the mouth of the Fraser, and only four entered McClinton Creek. It should be noted that all fishes entering McClinton Creek were examined. Experiments 2, 9, 11, 14, 16, and 23 also record a very small amount of straying for *Salmo* species and for *O. gorbuscha*. The fishes of expts. 9 and 11 entered streams at considerable distances—over 200 miles—from the stream of tagging, but it must be remembered that they were tagged in estuaries, and might never normally have spawned in the river where the tagging was done. The fish of expt. 2 entered a river about 100 miles from the river in which it was tagged. No details were given as to the part of the river in which the tagging was done.

There are then four experiments in which fishes marked in a particular stream are known to have entered another at a distance of 100 miles or more away (2, 9, 11, 28). On the other hand, in the various experiments of Taft and Shapovalov (1938: expts. 14, 16, 30) the straying was from one stream to another of comparable size and situation separated from the first by only five miles of open coast line. And in Davidson's (1934) experiment (23) the fishes marked in the Duckabush River strayed into two streams similar in size, one eight miles away and the other four miles, along the same shore of a narrow channel. All of the streams in this area were observed from time to time during the period of the experiment. A preliminary report of an experiment not listed in the table (Higgins, 1938) should also be noted here. Incomplete results on marking experiments on *O. nerka* conducted on the Karluk River and the Red River, Alaska, show that 5 per cent of recoveries of fishes marked in the Karluk are made in the Red River, and 0.6 per cent of the Red River fishes stray to the Karluk. Both streams are watched continuously; they are about 35 miles apart, on Kodiak Island.

Ward (1939a, b) has contended that marking experiments of this sort are of no value because of the small number of returns. A very large number of such experiments have now been performed, however, and, as we have seen, in virtually every case the results have been the same—namely, that the great majority of the fishes recovered in streams are found in the same streams which they left as young fishes. In view of this virtual unanimity, Ward's contention loses its force. We may then conclude that the majority of salmon reared and liberated in, or for *Salmo* species spawning in, a given stream will return for spawning to that same stream. We may also conclude provisionally that a limited and undetermined amount of straying to other streams will occur in certain cases. In most cases, this straying, when it has been observed to occur, has been only to streams near the stream of liberation.

Several attempts have been made to study the return of salmon to particular tributaries within a large river system.

These experiments are reported by Rich and Holmes (1928), Snyder (1931), Taft and Shapovalov (1938), and Clemens, Foerster, and Pritchard (1939). We will first consider experiments in which the marked fishes were hatched, reared, and liberated in the same stream from eggs spawned in that stream. These include two experiments of Rich and Holmes on *O. tschawytscha* in the Little White Salmon River, and one in Spring Creek, both tributaries of the Columbia entering the main stream approximately 150 miles from its mouth. In these experiments, altogether, 174,000 fishes were marked. Most of the recoveries were made in the sea or in the main Columbia River en route to the spawning grounds, but 99 fishes of the marked group succeeded in reaching the tributary of liberation, while three entered streams one to five miles up the river, and two entered streams five to fifteen miles down the river from that tributary. Snyder marked altogether 50,000 specimens of *O. tschawytscha* in Fall Creek on the Klamath River, California; 34 reached Fall Creek on the return migration, while three entered a stream seven miles below Fall Creek. Taft and Shapovalov marked *S. gairdnerii* in Fall Creek and found that 45 returned to that tributary, while none were recovered in any other; on the other hand, from a marking experiment in Beaver Creek, another tributary of the Klamath, three fishes appeared in streams 20 to 40 miles farther up the river, while 70 entered Beaver Creek. The results cited in expt. 19, Table 2, should again be noted here. According to the report of Clemens, Foerster, and Pritchard (1939), the entire run of *O. nerka* from Cultus Lake, a tributary of the Fraser River, was marked; 2500 marked fishes returned to the lake, and none was found in any other tributary of the Fraser, although a fairly careful watch was kept. In addition, few unmarked fishes appeared in Cultus Lake, indicating a very small infiltration from other areas.

A second type of experiment involves the marking of fishes reared and liberated in the same stream, but from eggs spawned in another tributary or even in another river system. Several experiments were performed by Rich and Holmes (1928) at Bonneville Hatchery, about 100 miles up the Columbia River. Eggs obtained from various tributaries of the Willamette River, a large tributary of the Columbia entering the latter about 75 miles from the sea, were used in these experiments. A total of 280,000 yearlings of *O. tschawytscha* were marked; only 6 returned to the hatchery where they were liberated, and 374 were taken in the main river, 105 of these above the hatchery. To this might be added a similar experiment with fishes from Willamette eggs reared and liberated in Herman Creek, near Bonneville. In this case only 20,000 were marked, and two returned to Herman Creek, while 46 were taken in the main river, six of these above Herman Creek. It should be noted that the tributaries from which the eggs came were in general at a greater distance from the sea than those in which the fishes were liberated; it should also be noted that, though reasonable watch was kept, none of these fishes was observed to enter the Willamette River. Snyder took eggs of *O. tschawytscha* from Mill Creek, a tributary of the Sacramento River somewhat over 150 miles from the sea, and reared the fishes in the Mt. Shasta hatchery, near the headwaters of the Sacramento. These fishes, numbering 15,400 were marked and liberated at the hatchery, in Sullaway Creek. None of the fishes ever reached Sullaway Creek again, but six entered Mill Creek, and fifteen appeared in Battle

Creek, several miles up the river from Mill Creek. There is a very brief report of a marking experiment of this type involving *O. nerka* (Higgins, 1933). Eggs from the Baker River, a tributary of the Skagit River, Washington, were transferred to Grandy Creek, farther up the Skagit; 48,000 young fishes from these eggs were marked. The entire runs of both Grandy Creek and the Baker River were watched, and marked fishes were observed to appear only in Grandy Creek. This report should be compared with the statements of Ward (1939), who claims that the lower temperature of the Baker River causes the entire run of *O. nerka* to be diverted into that tributary, and who states that in consequence planting experiments in tributaries above the Baker have failed.

Finally, another experiment of Snyder's is of interest. Using *O. tschawytscha*, he liberated yearlings (i.e. fishes ready for migration) which had been raised in Fall Creek (Klamath River) from Fall Creek eggs in the Shasta River near its mouth and in Jenny Creek. Both of these streams are tributary to the Klamath; the Shasta River is a relatively large stream, entering the Klamath about 180 miles from the sea, and Jenny Creek is smaller, opening about two miles below Fall Creek and fourteen miles above the Shasta. In each of two successive years, 25,000 fishes were liberated in each stream. Four of the Shasta fishes entered that river, and none was noted at other points. At Klamathon Racks, above the Shasta, where all fishes passing up the Klamath are normally trapped and may be examined, 137 of the Jenny Creek fishes appeared. Of these 85 were permitted to pass up the river; only one appeared in Jenny Creek, while 16 went to Fall Creek, and one to another nearby stream just below Jenny Creek.

Taking these experiments with the others, we may conclude that when eggs spawned in a particular area—the nature and size of which for any particular case is as yet undetermined—are hatched and the young fishes reared in that same area, the majority of these fishes will return to the area to spawn. The accuracy of this return probably varies with species, with locality, and possibly with other factors. No estimate of the extent or nature of the variation can be made at this time. The influence of hereditary factors and of early environment in determining this return cannot be estimated on the basis of the scanty data available. Rich and Holmes (1928) note that more accurate returns were made by *O. tschawytscha* in the Columbia when eggs were transferred from one stream to another which was similar in nature and location to the first than when transplants were made between streams differing considerably from one another. This appears generally to be the case, as noted by Powers (1939).

RACES OF SALMON

If the salmon from two different rivers do not mix to any great extent at the time of spawning—i.e. if the majority of the fishes return for spawning to the stream in which they were hatched and reared—then we might expect that noticeable differences would come to exist between the salmon inhabiting various streams. Measurements which show this to be the case were begun on the Pacific Coast by C. H. Gilbert (1913), who applied the method of scale measurements developed in Scotland for *S. salar* to a study of the life histories of *Oncorhynchus* species. In particular the studies on *O. nerka* in the various rivers of British Columbia are of great importance (Gilbert, 1914–24; Clemens and Clemens, 1925–1937; Clemens, 1938). Certain of these measurements

have been selected out of the mass of data presented in these reports; similar results would follow from a consideration of the others.

O. nerka in British Columbia may migrate to the sea in its first year—i.e. in the summer after the eggs are hatched, or may remain for one, two, or even three years in fresh water. The adult fish may return from the sea to fresh water in the fall of its third year, or may stay in the sea in a few cases until it reaches its seventh year. The run which enters a stream will be composed of fishes belonging to several different age groups. These age groups are determined by examination of the scales, and designated by a special notation (for details, see Gilbert and Rich, 1927). The age of the fish at maturity is denoted by an Arabic numeral, while the year of its life in which it descended to the sea is indicated by a subscript to that numeral. Thus, a fish which was hatched from eggs spawned in the fall of 1930, which descended to the sea in the summer of 1931 and which returned from the sea in the fall of 1933, would belong to the 3_1 group; if on the other hand the fish, hatched from 1930 eggs, remained in fresh water until the spring of 1933, then descended to the sea, to return in 1935, it would be placed in the 5_3 group.

We will first consider the age distribution in four British Columbia river systems. The Fraser River, some 700 miles in length, is by far the largest of these; it opens into the Strait of Georgia, about 15 miles north of the southern boundary of the province. Rivers Inlet is located just north of the northern end of Vancouver Island, a little more than 250 miles north and west of the mouth of the Fraser; into it opens a small river system perhaps 50 miles in length, which includes a lake a few miles from the sea. The Skeena River, about 250 miles long, opens into Chatham Sound, somewhat more than 200 miles north of Rivers Inlet. It is roughly paralleled over most of its course by the Nass River, which opens through Observatory Inlet into Chatham Sound a little over 50 miles to the north. In Table 3 are listed the average percentages, over a ten year period from 1926 to 1935 inclusive, of each age group in the runs of each of the four rivers. The numbers in each age-group were obtained by a study of scales from 1,000 to 2,000 individuals, taken at intervals throughout the course of the spawning run each year. It is evident that considerable differences exist. Thus, the fishes enter the southern streams at an earlier age, and leave the fresh water sooner in these rivers than in the northern ones. It is of great interest to note that the largest differences are those between the fishes of the two closest rivers—namely the Skeena, where 50 per cent of the run are 4_2 fishes, and the Nass, where only 20 per cent are to be found in this class, while the 5_3 fishes constitute 65 per cent of the total.

TABLE 3

Average percentages of age groups in runs of O. nerka to British Columbia rivers, 1926–1935 inclusive

(Calculated from data in Clemens and Clemens, 1926–37)

AGE GROUP	FRASER RIVER	RIVERS INLET	SKEENA RIVER	NASS RIVER
4_2	78	62	52	20
5_2	15	35	34	10
5_3	3	2	10	65
6_3	0	1	3	6

Measurements of the lengths of the same fishes are also available. These measurements have been analyzed by the author for the principal age groups in the runs of the Nass and Skeena Rivers for 1925, and for subsequent years as indicated in Table 4. The particular years have

been chosen on the assumption that the age at maturity is an inherited characteristic, and that therefore the progeny of the four-year-olds of 1925 will not appear until 1930. The significance of the table is not, however, dependent on this assumption. Table 5 shows the differences in length for each age group, together with the standard errors of these differences. The standard error is a measure of the amount of variation which might be expected in a series of samples by the operation of chance alone in the process of sampling. We will for present purposes consider a difference significant if it is as great as, or greater than, three times its standard error. This is equivalent to stating that such a difference would have arisen due to chance variations no oftener than once in approximately 400 cases. On this basis it is evident that, with the single exception of the 52 males in 1925, the fishes entering the Nass River are significantly larger than those entering the Skeena.

TABLE 4

Mean lengths (inches) of O. nerka in the Nass and Skeena Rivers in certain years, calculated for the principal age groups

(From data in Clemens and Clemens)

AGE GROUP		41		52		53	
Sex		M	F	M	F	M	F
Skeena River	1925	23.57	22.87	25.59	23.25	—	—
	1929	22.88	22.58	—	—	—	—
	1930	—	—	24.72	23.95	23.51	22.54
	1933	20.15	19.81	—	—	—	—
	1935	—	—	26.33	25.25	21.66	20.72
Nass River	1925	24.43	23.94	25.93	24.80	25.98	25.98
	1929	24.10	23.48	—	—	—	—
	1930	—	—	26.51	25.38	26.47	25.35
	1933	24.64	23.72	—	—	—	—
	1935	—	—	27.27	25.86	26.55	25.59

TABLE 5

Differences in mean length (inches) of O. nerka in the Nass and Skeena Rivers in certain years, with the standard errors of the differences

AGE GROUP	41		52		53	
Sex	M	F	M	F	M	F
1925	0.86 ± 0.1	1.07 ± 0.1	0.34 ± 0.2	1.55 ± 0.2	—	—
1929	1.22 ± 0.1	0.90 ± 0.1	—	—	—	—
1930	—	—	1.79 ± 0.1	1.43 ± 0.1	2.96 ± 0.1	0.81 ± 0.1
1933	4.48 ± 0.1	3.91 ± 0.1	—	—	—	—
1935	—	—	0.94 ± 0.2	0.61 ± 0.1	4.89 ± 0.1	4.86 ± 0.1

Similar results were obtained in the Alaska Peninsula region by Gilbert and Rich (1926). They tagged a large number of adults of *O. nerka* near the Shumagin Islands, south of the Alaska Peninsula, and at the same time took scales from these fishes. When the fishes were subsequently recovered in Alaskan Rivers, scale studies were made to determine the ages of the

fishes. Two such series are summarized in Table 6. These data will be discussed more extensively in a later section. Data are given by MacGregor (1923) and by Snyder (1931) which permit comparison of *O. tschawytscha* in the Sacramento and Klamath Rivers, California. These data are summarized, together with the differences, in Table 7.

In addition to these actual measurements, there are many observations supported by no published data which are to be found in the literature. Thus, Royal (Pacific Fisherman, 1937) is quoted as stating that the range of weight of *O. tschawytscha* in the Skagit River, Washington, is from 28 to 34 pounds, while in the nearby Green River the range is 12 to 14 pounds. He also states that *O. kisutch* in Lake Washington is smaller than in the Skykomish River, 25 miles to the north. Alm (1934) studied the various characteristics of *S. salar* in Swedish rivers and he concludes that each of these rivers is inhabited by a population possessing distinctive and characteristic habits of growth. Calderwood (1937) mentions that *S. salar* in the River Ness, Scotland, weighs from 17 to 40 pounds, while in the River Beauly, opening only 7 miles farther up Moray Firth, the weight is from 8 to 10 pounds.

There is also a small amount of material indicating the existence of differences between the salmon inhabiting various tributaries of the same river system. Gilbert is said to have noted as early as 1915 the existence of two separate groups of *O. nerka* in the Nass River run. Gilbert, and later Clemens, collected data on the fishes of Meziadin Lake and of Bowser Lake, the only two known spawning grounds for *O. nerka* in the Nass watershed. For example, in Clemens and Clemens (1935), we find data which show the mean length of the Meziadin males to be 2.9 ± 0.4 inches greater than for the Bowser males, while the females of the Meziadin group are 1.2 ± 0.3 inches longer, on the average, than those of the Bowser group. Earlier data in this series make it quite probable that Gilbert's early view is correct; namely, that each of the two tributaries is used as a spawning ground by a group of fishes differing from the group found in the other. D. L. Belding (personal communication) makes the statement that the average weight of two-year maiden specimens of *S. salar* is 10.5 pounds in the main Restigouche River, New Brunswick, while in the Matapedia River, a tributary, it is 12.5 pounds, and in the Upsalquitch, another tributary, the average weight is 8 pounds.

TABLE 6

Percentage of various age groups in samples of O. nerka tagged in the Shumagin Islands and recovered in Alaskan rivers, 1923

(Gilbert and Rich, 1926)

AGE GROUP	4₂	5₂	5₃	6₂	6₄	TOTAL NUMBER
Kvichak River	2	2	57	27	12	228
Nushagak River	4	54	30	12	0	71

TABLE 7

Means, differences in means, and standard errors of differences for several characters of O. tschawytscha in California rivers

(Calculated from data in MacGregor, 1923, and Snyder, 1931)

CHARACTER MEASURED	MEAN FOR KLAMATH	MEAN FOR SACRAMENTO	DIFFERENCE
Number of ova	3754	7440	3686 ± 220
Number of pyloric coeca	133.8	176.0	42.2 ± 3.2
Number of gill rakers on 1st branchial arch	23.5	27.4	3.9 ± 0.3
Length in cm	80.7	93.3	12.6 ± 0.3

Another characteristic which has been used to distinguish the salmon of different streams has been the time at which the mature fishes enter the river; thus, in the Columbia River, those fishes destined to travel far up the river enter early in the year, whereas those which will spawn in tributaries near the mouth enter at a later date. Rich and Holmes (1928) have shown that this time of entering fresh water is due to the influence of hereditary factors for *O. tschawytscha* in the Columbia. Fishes hatched from eggs transferred from a stream inhabited by spring run fishes to one inhabited by fall run fishes entered the Columbia in the spring, and conversely. White and Huntsman (1938), however, report an analogous experiment in which *S. salar* adopted the habits characteristic of the stream into which the eggs were introduced, instead of maintaining those of the stream in which the eggs would have been spawned.

As a result of observations such as these, the statement has been made that each stream is inhabited by a particular "race" of salmon. In view of the manifold interpretations of the term "race", it has been thought best to avoid its use. The conference on salmon problems, at Ottawa in 1938 (Huntsman *et al.*, 1939), decided that the term "local stocks" was preferable. It can, however, be said that significant differences in life history, size, or certain anatomical characteristics can be shown to exist between the fishes spawning in different streams. The question is discussed in some detail for Pacific species by Rich (1939) and generally in the discussions at Ottawa. The conclusion arrived at at this meeting may be quoted here. "The salmon of a given species may in a locality, e.g. a river, constitute a more or less distinct entity, for which the name 'stock' is to be preferred." (Huntsman, *et al.*, 1939.)

THE MOVEMENTS OF SALMON IN THE SEA

We have been concerned thus far with the return of salmon to a particular river or tributary. It has been shown that the majority of fishes marked in a given region return to that same region to spawn, and that the fishes spawning in one region differ from those spawning in another. This might conceivably come about in one of two ways. The young fishes might descend from the river into the sea and remain near the mouth of the river, ascending the same river later simply because it was the first to come to their notice. On the other hand, once in the sea, they might wander some distance away from the river in search of food and subsequently return to the same river by an active migration.

It should be worth while at this point, then, to consider the evidence which is at present available concerning each of these two hypotheses. Huntsman (1931) has described the distribution of the catch of *S. salar* in the Bay of Fundy. He notes that the fisheries depending upon the St. John River and Minas Basin salmon extend but a relatively short distance from the mouths of these rivers (Fig. 1). He states, here and later (Huntsman, 1938a), that the St. John salmon remain well within the zone in which the effects of the outflow of that river might be felt. No salmon tagged in the St. John has ever been taken in any part of the bay outside of this zone. Finally, Bay of Fundy salmon are never taken in the herring wiers at the mouth of the Bay.

However, the results summarized in Table 2 indicate that this situation is not general. Considering only the seven experiments (1, 5, 8, 9, 19, 21, and 28) in which ten or more fishes marked with a valid mark were taken in the sea, we find only two (9 and 19) in which 50 per cent or more of the recoveries were made in

the sea near the mouth of the river. When the dates on which these recoveries were made are considered, moreover, it is seen that most of the fishes taken were returning to the stream from the sea in the regular spawning run. But in view of the fact that sea recoveries depend to a great extent on the concentration of fishing activities in certain areas, confidence can be placed in these figures as indicators of the distribution of fishes in the sea only insofar as it may be supposed that, in general, fishing operations will tend to concentrate in the areas most frequented by fishes. The study of Alm (1934) indicating that all, or nearly all of the salmon (*S. salar*) from the rivers of Northern Sweden go to the southern Baltic and remain there until time to return to the streams gives further support to the view that salmon go considerable distances away from their natal streams in the sea.

Huntsman (1936) has contended that those fishes which stray far from the mouth of their natal stream become lost, and either enter other streams or remain in the sea. He cites in this connection the presence of very large salmon at the head of the Bay of Fundy, where there are no salmon streams; he presumes, without proof, that these fishes have been carried here by currents, and being lost have never sought spawning streams. More definite evidence in favor of this contention might be provided by those cases in which fishes have entered streams not those in which they were marked (Table 2, Nos. 2, 9,

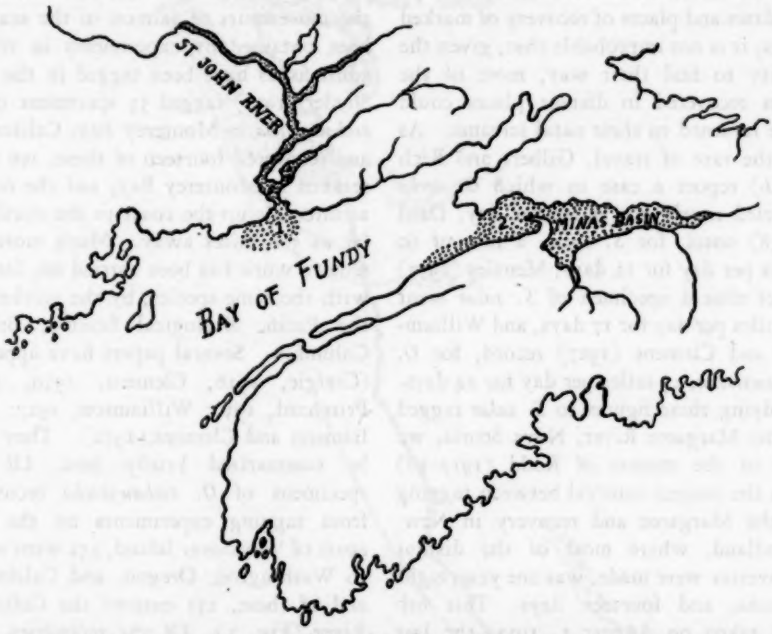


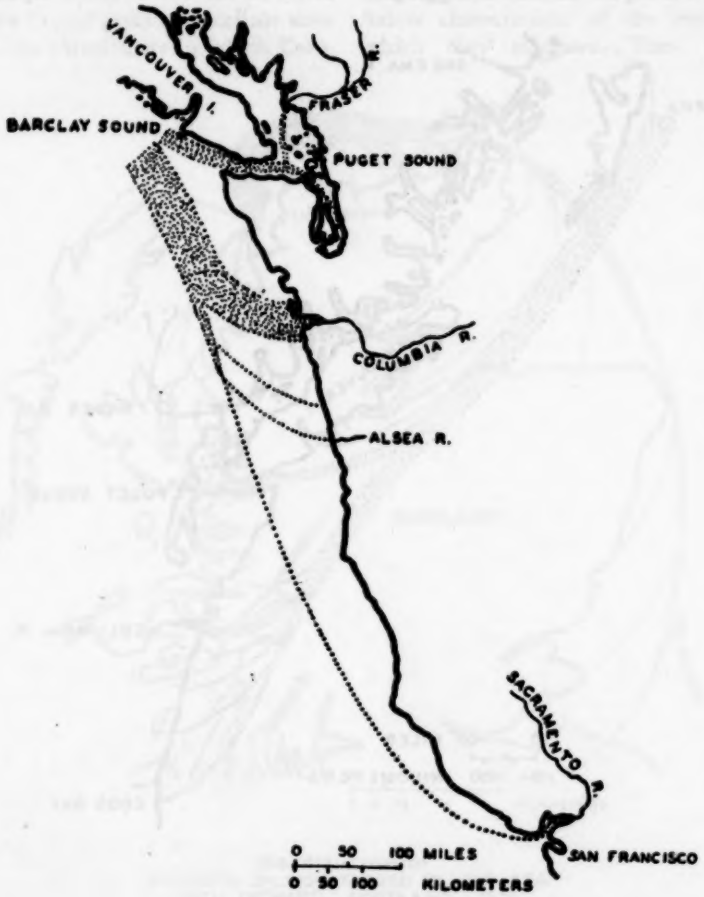
FIG. 1. DOTTED AREAS INDICATE REGIONS IN WHICH FISH (S. SALAR) FROM THE ST. JOHN RIVER (1) AND THE RIVERS OF THE MINAS BASIN (2) ARE TAKEN
(From Huntsman, 1931)

11, 14, 16, 23, 28, 30). But it must be recalled that only in four of these were the streams entered situated at any great distance, and that there is some reason to suspect the validity of three of these experiments. We must say that, at present there is very little definite evidence in favor of Huntsman's view.

On the other hand, considering the rate of travel of which a salmon is capable and the dates and places of recovery of marked fishes, it is not improbable that, given the ability to find their way, most of the fishes recovered in distant places could have returned to their natal streams. As for the rate of travel, Gilbert and Rich (1926) report a case in which *O. nerka* traveled nearly 100 miles per day; Dahl (1938) notes, for *S. salar*, a rate of 60 miles per day for 12 days; Menzies (1937) states that a specimen of *S. salar* went 24 miles per day for 17 days, and Williamson and Clemens (1927) record, for *O. tschawytscha*, 19 miles per day for 14 days. Applying these figures to *S. salar* tagged in the Margaree River, Nova Scotia, we find in the reports of Rodd (1917–38) that the longest interval between tagging in the Margaree and recovery in Newfoundland, where most of the distant recoveries were made, was one year, eight months, and fourteen days. This fish was taken on August 1, 1932; the last day in this year on which a tagged fish was taken along the coast near the Margaree was August 20. In order to cover the distance of 400 miles in 19 days, a rate of travel of 21 miles per day would be necessary. This is entirely possible. This is the only recorded case in which such an exact comparison can be made; in the only other valid case where relatively large numbers of sea recoveries were made (Snyder, 1931) all of the fishes taken in the sea had ample time to return to the Klamath. There is one single exception to these statements. Pritchard's (1939) experiment (Table 2, 28) has already been discussed. The 34 remote recaptures in this case were all made in the Georgia Strait region, at the time of the normal run to the Fraser River. Since six fishes were taken in the Fraser, the presumption is that all would have entered that river.

More definite information concerning the movements of salmon in the sea has been obtained by experiments in which adult fishes have been tagged in the sea. Snyder (1931) tagged 53 specimens of *O. tschawytscha* in Monterey Bay, California, and recovered fourteen of these; ten were retaken in Monterey Bay, and the others at intervals up the coast to the north, as far as 500 miles away. Much more extensive work has been carried on, largely with the same species, by the workers at the Pacific Biological Station, British Columbia. Several papers have appeared (Craigie, 1926; Clemens, 1930, 1932; Pritchard, 1930; Williamson, 1927; Williamson and Clemens, 1932). They will be summarized briefly here. Of 386 specimens of *O. tschawytscha* recovered from tagging experiments on the east coast of Vancouver Island, 252 went south to Washington, Oregon, and California, and of these, 231 entered the Columbia River (Fig. 2). Of 274 recoveries from fishes tagged on the west coast of the Queen Charlotte Islands, 20 appeared in Washington and Oregon, and of these 7 entered the Columbia River. Most of the rest of these fishes entered the rivers of the Georgia Strait-Pudget Sound region, especially the Fraser River (Fig. 3). Rich (personal communication) reports that *O. tschawytscha* has been shown to migrate from southeastern Alaska to the Columbia River. In this connection it is of the greatest interest to note that Rich and Holmes (1928) observed that a speci-

men of *O. tschawytscha* marked in the Columbia River went north as far as southeastern Alaska. We might also mention



DISTRIBUTION OF CHINOOK SALMON TAGGED IN THE SEA BARCLAY SOUND, BRITISH COLUMBIA, 1925 (WILLIAMSON, 1927)

FIGURE 1

ward entrances to the straits and channels of southeastern Alaska made extensive journeys north and south through the

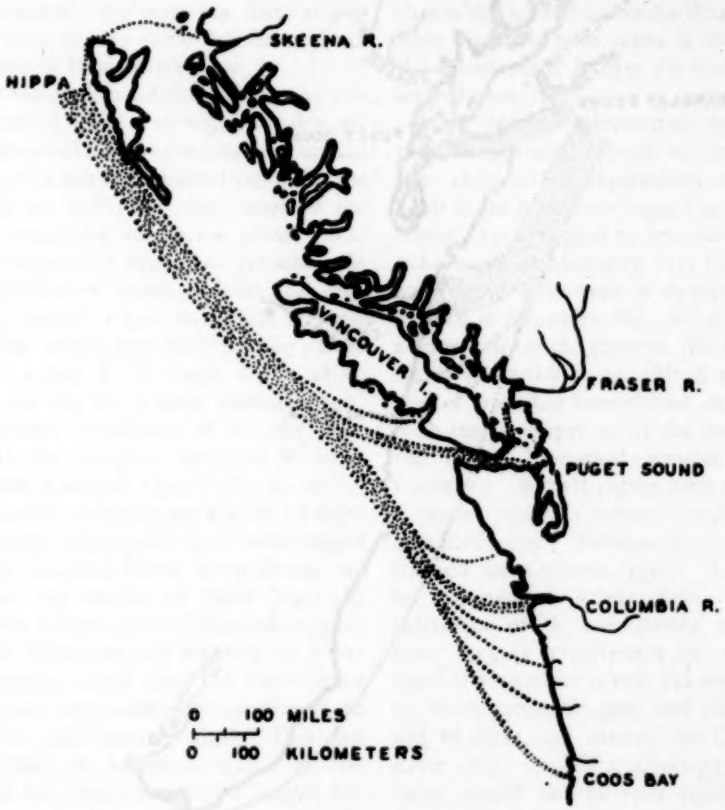
here the experiments of Rich (1926) and of Davidson and Christey (1938) which showed that salmon tagged at the sea-

complicated passages of this area. Finally, Sato (1937) has shown that *O. nerka*, *O. keta*, and *O. gorbuscha* tagged

in the sea in the Kamchatka region north of Japan disperse to many streams, some relatively remote from that region.

Only one report on the sea-tagging of

only along the coast of Newfoundland but to the Gulf of St. Lawrence shores of Canada as well. Port-aux-Basques is located at the southwestern tip of New-



DISTRIBUTION OF CHINOOK SALMON TAGGED IN THE SEA HIPPA ISLAND, BRITISH COLUMBIA, 1925 (WILLIAMSON, 1927)

FIGURE 3

North American Atlantic salmon has appeared. Belding (1939) reports that fishes tagged in the sea off Port-aux-Basques, Newfoundland, dispersed not

foundland, on one side of Cabot Strait, one of two entrances to the Gulf of St. Lawrence from the Atlantic. This report is of interest when it is realized that many

of the fishes tagged in various Canadian streams flowing into the Gulf of St. Lawrence were later recovered in Newfoundland.

Menzies (1939) gives an excellent summary of the experiments in which European Atlantic salmon have been tagged in the sea. Figure 4 shows the results of such an experiment (Menzies, 1937) involving the tagging of 1255 fishes at Loch Inchard, Scotland. Most of the recoveries were made along the northern Scottish coast, but one fish traveled 400 miles, to Whitby in England, while another went an equal distance across the North Sea to Sognefjord, Norway. Menzies notes that the scales of the fishes showed growth habits characteristic of the regions to which they migrated. These results, together with those of Dahl and Somme (1935–7) have led to the belief that there is a general movement of salmon from west to east, both on the Scottish and Norwegian coasts, at the time of the spawning migration. Menzies (1939) concludes: "The whole of the experiments are not

DISTRIBUTION OF ATLANTIC SALMON TAGGED IN THE SEA LOCH INCHARD, SCOTLAND. 1936 (MENZIES, 1937)

FIGURE 4

by any means inconsistent with a feeding ground at some indeterminate distance from which an easterly migration takes the fish to the coasts after their feeding period is finished."

Finally, we will consider the experiments of Gilbert (1924) and Gilbert and Rich (1926). They tagged a large number of specimens of *O. nerka* in the Shumagin Islands region, Alaska. Recoveries in an area where an intensive sea fishery is conducted, showed that most of the fishes taken in this region passed along the southern side of the Alaska Peninsula, around its tip to the northern side, and thence dispersed to all of the salmon streams of the Bering Sea shores of the Alaska Peninsula and of Bristol Bay (Fig. 5). Moreover, scales were taken from each fish at the time of tagging. Studies were subsequently made of the scales of those fishes which were recovered, and it was found that the life histories of these fishes were characteristic of the streams which they entered. Table 6 gives the results of one such series; it was known from other observations that most of the Kvichak fishes normally spend two years in fresh water and go to sea in their third year; 84 per cent of the recoveries in the Kvichak showed this habit. On the other hand, most Nushagak fishes normally go to sea in their second year; 58 per cent of the recoveries showed such a record on their scales. Other differences are also evident from the table.

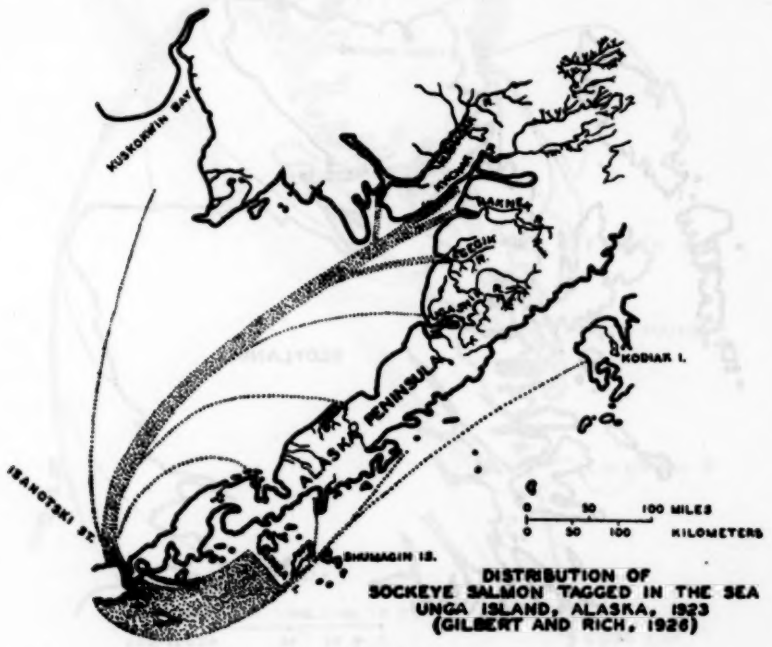


FIGURE 5

[*Note:* A very large number of fish are taken on the south side of Isanotski Strait, due to intensive fishing operations there. Rich (personal communication) thinks it probable that the salmon pass northward through Unimak Pass, 100 miles to the west, rather than through Isanotski Strait, as indicated here.]

THE HOMING INSTINCT

It will be recalled that at the beginning of the previous section two alternative hypotheses were proposed. It was suggested that the majority of fishes from a given stream never went far from that stream in the sea, with the corollary that if they did wander off, they became lost, and were unable to return except by accident to that stream. We have seen that, while in the case of certain rivers of the Bay of Fundy, there are indications that this may be the case, there are numerous data which indicate that a certain fairly large number of fishes may leave the vicinity of the natal stream. It has been shown that these fishes would have time to return to this same stream, given the ability to find it. It has also been shown in certain cases that large-scale movements of fishes over distances of several hundred miles take place; in a few instances, different fishes have been shown to cover the same lengthy migratory courses in opposite directions, as, for example, the movements of *O. tschawytscha* from the Columbia River to southeastern Alaska, and from Alaska to the Columbia River. Finally, in two cases, numbers of sea-tagged fishes have traversed considerable distances and later entered streams normally inhabited by fishes having life histories similar to those shown by the scales of the tagged fishes.

All of these facts are much more easily explained by the second hypothesis, namely, that fishes may leave the general vicinity of their natal streams and travel considerable distances in the sea, but that the majority of such fishes subsequently return to the same stream. In addition, certain results cited in earlier sections are in accord with this hypothesis. That the salmon possesses some ability to follow a definite migratory course is shown by the fact that a certain degree of return to individual tributaries has been demonstrated in certain large river systems. If we assume that any or all of the anatomical and other distinctions demonstrated to exist between the populations of different streams are hereditary or are determined by the fresh-water environment, then it necessarily follows that no great admixture of populations between the two streams at spawning time can take place. In certain geographical situations it is absolutely essential that the majority of the fishes definitely choose the stream from which they originally entered the sea, if this admixture is to be prevented. This is true for *O. nerka* in the Nass and Skeena Rivers, for example, where the Nass fishes must pass near the mouth of the Skeena on their riverward migration; nevertheless constant differences in life history between the stocks of the two streams have been observed over a period of 25 years at least. Other examples are numerous.

It is of course true, as Huntsman (1937) has pointed out, that the most convincing proof of this second hypothesis which could be provided would consist of an experiment in which fishes indisputably originating in a certain stream were tagged in the sea and subsequently recovered in that same stream. It is to be hoped that this experiment will at some time be performed, although the technical difficulties are very great. It is also true that most of the experiments described in this paper were not designed for the express purpose of determining the sea range of salmon which subsequently return to their natal streams. In consequence, we cannot regard this particular question as entirely settled. Furthermore, there are undoubtedly differences between the individual species treated here which will appear on further study. It is, however, the opinion of the author that the weight

of the evidence at present available is distinctly in favor of the parent stream theory, which we may state thus: Anadromous salmon or trout hatched and reared in a particular region will, upon returning to fresh water, return in the great majority of cases to that same region, even from considerable distances. It is to be hoped that this will be more extensively tested in the future. It is also especially to be desired that attempts will be made to define more closely the nature and size of the region to which a given group of fishes will return, and to study the variations with species and locality. The inadequacies in our knowledge of these and other matters were pointed out by the participants in the Ottawa symposium (Huntsman *et al.*, 1939).

THE NATURE OF THE HOMING INSTINCT

The existence of a certain ability to follow a definite migratory course leads naturally to the question, what sense or senses are involved? Very few attempts appear to have been made to answer this question. Ward (1921a, b, 1939a, b) studied *O. nerka* in the Copper River, Alaska, and concluded that when presented with a choice between two tributaries, the salmon invariably chooses the one with the cooler water. He has also applied this to *O. nerka* in the Skagit River, Washington. Powers (1939) has attributed the direction taken by *O. nerka* to (a) gradients of salinity in the sea, and (b) gradients of carbon dioxide tension in the sea and in the rivers. Although the suggestions made by these writers are of some value in indicating possibilities, neither has taken into consideration the fact that a run of fishes, whether in the sea or in a river, may divide, some passing into one river or tributary while others continue in their previous course. Neither author is willing to agree with the parent stream theory as stated above. Craigie (1926) sectioned the olfactory nerves of specimens of *O. nerka* captured in the Georgia Strait region; his results were inconclusive. We must then say that at present we know little or nothing about any mechanism which might enable the salmon to find his way to a particular stream or tributary. Indeed, we may say, as Sumner (1939) has, that it is difficult to see how any known sense or combination of senses would be adequate, in view of the fact that variations in a certain property of a given stream might be greater from year to year than would be the differences between that stream and a nearby one. Studies directed at this feature of the "homing" question should prove of the greatest interest.

SUMMARY

1. Specimens of *S. salar*, *S. gairdneri*, *O. nerka*, *O. tschawytscha*, *O. gorbuscha*, and *O. kisutch* reared, marked, and liberated in a particular river have been shown to return, in the great majority of cases, to that same river.

2. There are very few cases in which it has been shown convincingly that individuals of any of these species have entered streams 100 or more miles from the one in which they were reared.

3. There is some evidence that fishes reared in small rivers will stray in small numbers to similar streams not more than 50 miles away.

4. When eggs spawned in a particular tributary are hatched and the young fishes reared in that same tributary, most of the adult fishes will return to the tributary (*O. nerka*, Fraser River; *O. tschawytscha*, Columbia River).

5. Demonstrable differences in life history, in certain anatomical features, or in both exist between salmon of the same species breeding in adjacent rivers (*O.*

nerka, *O. tschawytscha*, *O. kisutch*, Pacific coast of North America; *S. salar*, Scotland, Sweden).

6. Similar differences exist between the salmon inhabiting different tributaries of the same large river system (*S. salar*, New Brunswick; *O. nerka*, British Columbia; *O. tschawytscha*, Columbia River).

7. Except for those cases in which the principal fishery depends upon the riverward migration of fishes, and centers around the mouth of the river, the majority of recoveries of marked fishes at sea have been at considerable distances from the river in which they were marked (*S. salar*, Sweden, Scotland, Canada; *O. tschawytscha*, California).

8. Practically all of the fishes recovered in the sea at considerable distances from their natal streams could have returned to them in time to enter with the normal run, granted the ability to find the stream.

9. Fishes tagged in the sea in certain areas will subsequently disperse to a variety of streams, some at considerable distances (*O. nerka*, *O. keta*, *O. gorbuscha*, Japan; *O. nerka*, Alaska; *O. tschawytscha*, British Columbia, California; *S. salar*, Newfoundland, Scotland, and Norway).

10. Young specimens of *O. tschawytscha* marked in the Columbia River may go north as far as southeastern Alaska; adults tagged in southeastern Alaska or farther south may go to the Columbia River.

11. Specimens of *S. salar* tagged in the sea off Scotland and of *O. nerka* tagged in Alaska have later appeared in streams remote from the region of tagging; scales from these fishes gave evidence of life histories otherwise known to be characteristic of the streams they later entered.

12. The hypothesis most compatible with these facts is the following: Anadromous salmon and trout hatched and reared in a particular region will, when seeking fresh water to spawn, seek out and return in the great majority of cases to the same region, even from considerable distances.

13. No mechanism is known by means of which fishes could so return.

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LIST OF LITERATURE

Note: A number of articles are cited below to which specific reference was not made in the text. These articles substantiate in general the conclusions given there.

Alm, G. 1931. Resultaten av laxmärkningarna i Sverige åren 1914–1926. *Ny Svensk Fiskeritidskr.*

——. 1934. Salmon in the Baltic Precincts. *Conseil Permanent International pour l'exploration de la Mer, Rapports et Procès-verbaux des Réunions*, 92: 1–63.

Belding, D. L. 1939. The Atlantic salmon of the Gulf of St. Lawrence. *Migration and Conservation of Salmon.* Publ. of the Am. Assn. Adv. Sci., No. 8: 26.

Bigelow, H. B., and W. W. Welsh. 1925. Fishes of the Gulf of Maine. *U. S. Bureau of Fisheries, Bull.* 48.

Calderwood, W. L. 1903–08. Contributions to the life-history of the salmon, as observed by means of marking adult fish (second to sixth papers). *Scotland Fishery Board, Part II, Salmon Fisheries.* 22nd to 27th Annual Reports.

——. 1908. The Life of the Salmon. *London.* Pp. 75–84.

——. 1930. Salmon and Sea Trout. *London* (E. Arnold and Co.).

——. 1931. Salmon Hatching and Salmon Migrations. *London* (E. Arnold and Co.). Pp. 59–90.

——. 1937. Homing instinct in salmon. Modern skepticism on the homing instinct and the theory of separate races. *Salmon and Trout Magazine*, No. 88: 207.

Chamberlain, F. M. 1907. Some observations on salmon and trout in Alaska. *U. S. Bureau of*

Fisheries, Doc. 617: 76–89. *Report of Commissioner of Fisheries*, 1906.

——, and W. T. Bower. 1913. Fishery Industries. *Fishery and Fur Industries of Alaska*, 1912. *U. S. Bureau of Fisheries, Doc.* 780: 21–31. *Report of Commissioner of Fisheries*, 1912.

Clemens, W. A. 1930. Pacific salmon migration: The tagging of coho salmon on the east coast of Vancouver Island, 1927–8. *Canada Biological Board Bull.* 15: 19 pp.

——. 1932. Pacific salmon migration: The tagging of spring salmon on the east coast of Vancouver Island in 1927 and 1928, with notes on the incidental tagging of other fish. *Ibid.*, 27: 10 pp.

——. 1938. Contributions to the life-history of the sockeye salmon. No. 23. *Report of the British Columbia Fisheries Department*, 1937.

——, and L. S. Clemens. 1925–27. Contributions to the life-history of the sockeye salmon. Nos. 11–22. *Ibid.*, 1924–36.

——, R. E. Foerster, and A. L. Pritchard. 1939. The migration of Pacific salmon in British Columbia waters. *The Migration and Conservation of Salmon.* Publ. of the Am. Ass. Adv. Sci., No. 8: 51.

Cobb, J. N. 1917. Pacific salmon fisheries. *U. S. Bureau of Fisheries, Doc.* 839: 15–18. *Report of the Commissioner of Fisheries*, 1916. App. III.

Craigie, E. H. 1926. A preliminary experiment on the relation of the olfactory sense to the migration of the sockeye salmon (*Oncorhynchus nerka* Walbaum). *Transactions of the Royal Society of Canada*, Ser. III, 20, Sect. V; 215–224.

Dahl, K. 1938. A review of recent salmon-marking experiments in Norway. *Conseil Permanent International pour l'Exploration de la Mer, Rapports et Procès-verbaux des Réunions.* 108, III: 3.

——, and S. Somme. 1935–37. Experiments in salmon-marking in Norway. *Skr. utg. av det Norske Vid. Akad. i Oslo. I. Matem.-Naturv.*

Davidson, F. A. 1934. The homing instinct and age at maturity of pink salmon (*Oncorhynchus gorbuscha*). *U. S. Bureau of Fisheries, Bull.* 48: 27–39.

——. 1937. "Migration" and "homing" of Pacific salmon. *Science*, 86: 55.

——, and L. S. Christy. 1938. The migration of pink salmon in the Clarence and Sumner Straits regions of southeastern Alaska. *U. S. Bureau of Fisheries, Bull.* 48: 643–66.

Foerster, R. E. 1937. The return from the sea of sockeye salmon (*Oncorhynchus nerka*) with special reference to percentage survival, sex proportions, and progress of the migration. *Journal of the Biological Board of Canada*, 3: 26–42.

Fraser, C. M. 1920. Growth rate of the Pacific salmon. *Transactions of the Royal Society of Canada.* Ser. III, 13, Sect. V: 163–226.

Gilbert, C. H. 1913. Age at maturity of Pacific Coast salmon of the genus *Oncorhynchus. U. S. Bureau of Fisheries, Bull.* 32: 1–22.

——. 1914–24. Contributions to the life-history of the sockeye salmon. Nos. 1–10. *Report of the British Columbia Fisheries Department*, 1913–1923.

——. 1924. Experiment in tagging adult red salmon, Alaska Peninsula Fisheries Reservation, summer of 1922. *U. S. Bureau of Fisheries, Bull.* 39: 39–50.

——, and W. H. Rich. 1926. Second experiment in tagging adult red salmon, Alaska Peninsula Fisheries Reservation, summer of 1923. *Ibid.*, 42: 27–75.

Higgins, E. 1933. Progress in biological inquiries in 1932. Appendix, *Report of the Commissioner of Fisheries.* (*U. S.*) 1932.

——. 1937. Progress in biological inquiries in 1936. *Ibid.*, 1936.

——. 1938. Progress in biological inquiries in 1937. *Ibid.*, 1937.

Huntsman, A. G. 1931. The maritime salmon of Canada. *Canada Biological Board, Bull.* 21: 99 pp.

——. 1936. Return of salmon from the sea. *Ibid.*, 51.

——. 1937a. "Migration" and "homing" of Salmon. *Science*, 85: 313.

——. 1937b. "Races" and "homing" of salmon. *Ibid.*: 582.

——. 1938a. Sea movements of Canadian Atlantic salmon kelts. *Journal of the Fisheries Research Board of Canada*, 4: 96–135.

——. 1938b. Return of salmon to their home streams. *Pacific Fisherman*, 36, No. 2: 27.

——. 1938c. "Spawning urge," "homing instinct," and "waiting" in salmon return. *Nature*, 141: 421–422.

——. 1938d. Sea behavior in salmon. The case against an hereditary homing instinct. *Salmon and Trout Magazine*, 90: 24.

——. 1939. Migration and conservation of Atlantic salmon for Canada's maritime provinces. *Migration and Conservation of Salmon.* Publ. of the Am. Assn. Adv. Sci., No. 8: 32.

Huntsman *et al.* 1939. Conference on salmon problems. *Ibid.*: 86.

Jordan, D. S. 1925 Fishes. *New York* and *London.* 305–310.

Kendall, W. C. 1935. The fishes of New England. The salmon family. Part 2. The Salmons.

Boston Society of Natural History, Memoirs 9, No. 1.

MacGregor, E. A. 1923. A possible separation of the river races of king salmon in ocean-caught fish by means of anatomical characters. *California Fish and Game*, 9: 138.

Marsh, M. C., and J. N. Cobb. 1908–11. Fisheries of Alaska in 1907–10. *U. S. Bureau of Fisheries Doc.* No. 623: 27–29; No. 645: 57; No. 730: 26; No. 746: 26. *Report of the Commissioner of Fisheries*, 1907–10.

Menzies, W. J. M. 1937. The movements of salmon marked in the sea. I. Northwest coast of Scotland, 1936. *Scotland, Fishery Board. Salmon Fisheries* 1937, No. 1.

——. 1938a. The movements of salmon marked in the sea II. West coast of Sutherland, 1937. *Ibid.*, 1938, No. 1.

——. 1938b. Some preliminary observations on the migration of salmon (*Salmo salar*) on the coasts of Scotland. *Conseil Permanent International pour l'Exploration de la Mer, Rapports et Procès-verbaux des Réunions*, 108, III: 18.

——. 1939. Some preliminary observations on the migrations of the European salmon. *Migration and Conservation of Salmon.* Publ. of the Am. Assn. Adv. Sci., No. 8: 13.

Pacific Fisherman. 1937. Return of Pacific salmon to their home streams (a symposium). *Pacific Fisherman*, 35, No. 10: 31. No. 11: 39. No. 12: 24.

Powers, E. B. 1939. Chemical factors affecting the migratory movements of the Pacific salmon. *Migration and Conservation of Salmon.* Publ. of the Am. Assn. Adv. Sci., No. 8: 72.

Pritchard, A. L. 1930. Pacific salmon migration: the tagging of the pink salmon and the chum salmon in British Columbia in 1928. *Canada Biological Board, Bull.* No. 14, 17 pp.

——. 1937. The findings of the British Columbia pink salmon investigation. II. Marking experiments and natural propagation. *Canada, Progress Reports of the Pacific Biological Station and the Pacific Fisheries Experiment Station*, No. 34: 8–12.

——. 1938. Transplantation of pink salmon (*Oncorhynchus gorbuscha*) into Masset Inlet, British Columbia in the barren years. *Journal of the Fisheries Research Board of Canada*, 4: 141.

——. 1939. Homing tendency and age at maturity of pink salmon (*Oncorhynchus gorbuscha*) in British Columbia. *Ibid.*: 233.

Rich, W. H. 1926. Salmon tagging experiments in Alaska, 1924 and 1925. *U. S. Bureau of Fisheries, Bull.* 41: 109–146.

——. 1932. Salmon tagging experiments in alaska, 1930. *Ibid.*, 47.

——. 1937a. "Homing" of Pacific salmon. *Science*, 85: 477.

——. 1937b. "Races" and "homing" of Pacific salmon. *Ibid.*, 86: 122.

——. 1939. Local populations and migration in relation to the conservation of Pacific salmon in the western states and Alaska. *Migration and Conservation of Salmon.* Publ. of the Am. Assn. Adv. Sci., No. 8: 45.

——, and H. B. Holmes. 1918. Experiments in marking young chinook salmon on the Columbia River. *U. S. Bureau of Fisheries, Bull.* 44: 215–264.

——, and F. G. Morton. 1919. Salmon-tagging experiments in Alaska, 1917–8. *Ibid.*, 45.

——, and A. J. Suomela. 1917. Salmon-tagging experiments in Alaska 1916. *Ibid.*, 43, Pt. 2: 71–104.

Rodd, J. A. 1917–38. Report of the Director of Fish Culture. *Canada, Department of Fisheries Annual Reports* from 1916.

Rushell, E. S. 1937. Fish migrations. *Biological Reviews*, 12: 320–337.

Rutter, C. 1903. Natural history of the quinnat salmon. *U. S. Fish Commission, Bull.* 22: 205.

Sato, R. 1937. On new migratory courses of salmon (*Oncorhynchus*) cleared by the tagging experiments in the fishing ground of northern north Pacific 1936. I. Red Salmon (*Oncorhynchus nerka* (Walb)). II. *Oncorhynchus keta* (Walb). III. *Oncorhynchus gorbuscha* (Walb). *Bull. of the Japanese Society of Scientific Fisheries*, 6: 171, 251, 299.

Shapovalov, L. 1937. Trout and salmon marking in California. *California Fish and Game*, 23: 205.

——. 1939. Homing instinct in Salmonidae. *Proceedings of the 6th Pacific Science Congress.* (In Press.)

Snyder, J. O. 1921. Three California marked salmon recovered. *California Fish and Game*, 7: 1.

——. 1922. Return of marked king salmon grilse. *Ibid.*, 8: 102.

——. 1923. Second report on the return of king salmon marked in 1919 in the Klamath River. *California Fish and Game*, 9: 1.

——. 1924. Third report on the return of king salmon marked in 1919 in the Klamath River. *Ibid.*, 10: 110–114.

——. 1931. Salmon of the Klamath River, California. *California Division of Fish and Game, Fish Bull.* No. 34: 130 pp.

——, and E. C. Scofield. 1924. An experiment relating to the homing instinct of king salmon. *California Fish and Game*, 10: 9–17.

Sumner, F. B. 1939. Human psychology and some

things that fishes do. *Scientific Monthly*, 99: 245.

TAFT, A. C. 1936. The Waddell Creek experimental station for trout and salmon studies. *California Fish and Game*, 22: 99.

——. 1937. Marked silver salmon from Waddell Creek caught near Fort Bragg. *Ibid.*, 23: 177.

——, and L. SHAPOVALOV. 1938. Homing instinct and straying among steelhead trout and silver salmon. *Ibid.*, 24: 118.

WARD, H. B. 1921a. Some of the factors controlling the migration and spawning of the Alaska red salmon. *Ecology*, 2: 235–54.

——. 1921b. Some features in the migration of the sockeye salmon and their practical significance. *Transactions of the American Fisheries Society*, 50: 387–416.

——. 1939a. Psychology of salmon. *Proceedings of the Washington Academy of Sciences*, 29: 1.

——. 1939b. Factors controlling salmon migration. *Migration and Conservation of Salmon*. Publ. of the Am. Assn. Adv. Sci., No. 8: 60.

WHITE, H. C. 1936. The homing of salmon in Apple River, N. S. *Journal of the Biological Board of Canada*, 2: 391–400.

——, and A. G. HUNTSMAN. 1938. Is local behavior in salmon hereditable? *Journal of the Fisheries Research Board, Canada*, 4: 1–18.

WILLIAMSON, H. C. 1927. Pacific salmon migrations. Report on the tagging operations in 1925. *Canada Biological Board. Contributions to Canadian Biology*, 3: 265–306.

——, and W. A. CLEMENS. 1932. Pacific salmon migration. The tagging operations at Quatsino and Kyuquot in 1927, with additional returns from the operations of 1925 and 1926. *Canada Biological Board, Bull.* No. 26: 161 pp.

EFFECTS OF FEEDING THYROID SUBSTANCE (*Concluded*)

By B. AUBREY SCHNEIDER

Department of Biology, School of Hygiene and Public Health of the Johns Hopkins University, Baltimore

THE EFFECTS OF THYROID ON TISSUES IN GENERAL

ATTEMPTS have been made to show the universal action of thyroid on protoplasm by treating isolated vertebrate, invertebrate, and plant tissues with extracts of the vertebrate gland. Thus Carrel (1913) found that connective tissue (periosteum) grew faster *in vitro* under the influence of thyroid than without thyroid. Ebeling (1924) found that thyroid epithelium in pure culture secreted substances which, like extracts of the thyroid gland, accelerated cell division of fibroblasts *in vitro*. Sato (1930) demonstrated that synthetic thyroxin in 1:100,000 dilution accelerated the growth of cultivated heart tissue and fibroblasts of the chick embryo, as well as cultivated lung tissue of the rabbit embryo. In 1:500,000 dilution, synthetic thyroxin also stimulated growth of cultivated chicken myxosarcoma *in vitro*.

Hopping (1931) found that the blood from an alligator injected with thyroxin (Squibbs) 3 days previously to the test showed an increase in metabolism of from 150 to 190 percent above the control (normal alligator's) blood. Davis, Da Costa and Hastings (1934), studying the tissue metabolism of excised frog heart, found that after treatment for 24 hours with a concentration of 1 mgm. per 100 cc. of thyroxin, the mean oxygen consumption had increased 55 percent, while the control had decreased 17 percent. Markowitz and Yater (1932) made a study of the action of thyroxin on cultures of pulsating fragments of heart muscle removed from two-day-old chick embryos. The thyroxin (1:500,000 dilution) increased the frequency of pulsations and contractions of the isolated tissues from 100 per minute to 226 per minute, after 24 hours of treatment. Gerard and McIntyre (1932) fed young dogs with 0.6 gm. of desiccated thyroid per kilo per day for a period of 3 to 6 weeks. At the end of the feeding period, it was found that isolated liver, heart, and vagus nerve tissues had an average increase of 25 percent in oxygen consumption, as compared with the oxygen consumption of identical tissues from normal dogs.

The experiments of Hicks (1932) showed that the oxygen consumption of finely minced rat muscle tissue at 37°C. was increased by 20 per cent when the animal received hypodermic injections of 0.7 mg. thyroxin weekly for 6 weeks prior to the isolation of tissue. Dye (1933) studied the effects of thyroxin on tissue respiration, and found that when pups approximately 3 months old were fed large doses of thyroxin (168 mgm. each in 35 days), their isolated muscle tissues showed an increase in oxygen consumption of 50 percent as compared with oxygen consumption of similar tissues from normal

dogs. McEachern (1935) reported some experimental work on the metabolism (as measured by Warburg's method) of diaphragm muscle, and of hepatic and renal tissues of the white rat following subcutaneous administration of thyroxin. small (up to 28 percent) and variable increase in the respiration of hepatic and renal tissues. The respiration of muscle tissues underwent no significant change. Induction of hyperthyroidism by multiple injections of the above-mentioned

TABLE 1

Comparison of total metabolism of normal and hyperthyroid animals to QO_2 and QN_2/G of their isolated tissues

Determination of tissue metabolism based on 1-hour period. (From McEachern, D., 1935. Bull. Johns Hopkins Hospital, Vol. 56, pp. 145–179.)

DATE	THYROXINE			ANIMAL			KIDNEY			LIVER			DIAPHRAGM		
	Milligrams per kilogram	Number of doses	Number of days	B.M.R. cm³ per gram per hour			QO_2	Per cent increase†	QN_2/G	QO_2	Per cent increase†	QN_2/G	QO_2	Per cent increase†	QN_2/G
				Normal	After thyroxine	Per cent increase†									
Normal															
1933															
1/20				1.28			29.10			10.63			4.69		
1/26				1.11			24.62		4.72	8.54		1.16	4.42		4.36
2/15				1.31			21.40		3.41	9.87		2.32			4.21
3/13				1.13			21.00		2.68	7.26		1.04	6.13		4.18
3/8				1.02			27.10		2.82	7.70		1.16	5.37		5.43
2/22				1.26			20.92		1.35	10.53			5.59		4.42
Mean.....				1.18			24.02		2.99	9.09		1.42	5.24		4.52
Hyperthyroid															
3/23	1.0*	6	6	1.17	1.84	57.2	44.90	84.0	3.92	13.80	58.6	1.63	7.13	40.3	—
2/3	10.0	3	7	1.16	1.93	66.4	40.50	67.0	7.48	15.60	79.0	1.80	6.23	22.6	4.12
1/10	10.0	3	4	0.97	1.98	104.0	36.00	47.6	—	15.55	79.0	—	6.12	20.4	—
3/7	2.5	12	14	1.14	2.09	83.5	37.24	53.6	4.92	12.78	47.0	—	8.50	67.3	3.55
1/25	20.0	4	8	1.18	2.26	91.6	34.50	42.2	7.35	11.56	33.0	4.72	8.55	68.0	3.38
3/6	2.5	11	12	1.08	2.30	113.0	35.50	45.6	4.66	10.90	25.3	1.25	10.33	103.5	4.10
2/9	0.66*	9	9	1.23	2.57	109.0	42.90	75.8	5.17	12.70	46.0	1.26	9.24	82.0	5.63
Mean.....				1.13	2.14	89.3	37.77	57.2	5.70	13.18	45.0	2.13	8.01	52.7	4.16

* Grams B.D.H. thyroideum siccum by mouth per day.

† Incease above average of normal series.

Control experiments were made in each case with tissues from normal animals. At varying time intervals (22 hours to 8 days) following the administration of a single dose of 10.0 mgm. thyroxin per kilogram of body weight, there was a dosage, brought about large and constant increases in tissue respiration. In 12 experiments, the mean increase was 46 percent for kidney, 73 per cent for liver and 75 percent for muscle. A summary of McEachern's work is shown in Table 1.

Work on thyroid treating of invertebrate tissues has yielded a variety of noteworthy results. The respiration of fresh, dried, and powdered tissues of various invertebrates with and without addition of thyroid extract, was measured by the Barcroft-Warburg technique by Ashbel (1935). It was found that in the case of eggs of *Bombyx mori* during aestivation and incubation, thyroid extract caused an increase of oxygen consumption up to 23 percent. On hibernating eggs of the same form the effect of thyroid extract was even more marked, the oxygen consumption being increased up to 3700 percent. With whole and various portions of the silk glands of *Bombyx mori*, oxygen consumption was increased up to 15 percent. An increase up to 300 percent in oxygen consumption was noted with thyroid treating of unfertilized eggs and with ovaries of the echinoderm, *Spherocinus granularis*. With fertilized eggs in all stages of development in the crustaceans *Carcinus moenas*, *Eupagurus prideauxii*, *Portunus corrugatus*, and *Portunus holstatus*, an increase up to 300 percent was noted in oxygen consumption. With the fertilized eggs of the mollusk, *Aplepia limacina*, an increase up to 200 percent was noted. With the ovary of the tunicate, *Ciona intestinalis*, an increase of oxygen consumption up to 360 percent was noted. In every case the action of the thyroid extract was identical on the uninjured and freshly macerated tissues. The action of the thyroid extract was even more marked on suspensions of tissues which had been dried and powdered. Increases in oxygen consumption of dried tissues were noted as follows: up to 5,000 percent with powdered eggs of *Bombyx mori;* 3,000 percent with powdered silk-glands of *Bombyx mori;* 9,300 percent with powdered ovary of *Echinoderma;* 4,000 percent with powdered eggs of crustaceans; 2,700 percent with powdered eggs of mollusks; and 30,000 percent with powdered ovary of tunicates. In the case of suspensions of powdered tissues which had been standing for months (eggs and silk glands of *Bombyx mori*) and showed almost zero oxygen consumption, the addition of thyroid extract caused an almost immediate restoration of oxygen consumption. All the experiments were made with the thyroid extract "Elyteran" (Bayer). Synthetic thyroxin appeared to have no effect on the oxygen consumption of these invertebrate tissues.

Studies on thyroid treating of plant tissues have effectively contributed to our knowledge of the effects of the hormone on protoplasm in general. Imshenetskii (1932) studied the effect of thyroid extract (thyroidin) on *Saccharomycodes ludwigii*, *Mucor guilliermondii*, *M. racemosus*, *M. ramonnianus*, *Rhisopus nigricans*, *Bacillus megatherium* and *B. mycordes* by adding dilute solutions (0.02 percent to 3.0 percent) of the extract to the food medium. It was found that spore formation in yeasts and molds was stimulated, and their rate of reproduction was increased. The effect on spore formation in bacteria was slighter, and no effect on the rate of reproduction was noted. A 0.5 percent concentration was found to be optimal, and the greatest stimulation occurred during the first 48 hours of treatment. Thyroxin in concentrations of 1:9,000, 1:6,000 and 1:3,000 had no effect on spore formation or reproduction of any of the above-mentioned forms. Buddington (1919) in his experiments with bulbs of *Allium* grown in Pfeffer's solution discovered that the growth of the root tips was retarded in proportion to the amount of thyroid material used. He noted further that the early leaves were not affected by the presence of thyroxin, and that general growth was not affected

by iodine compounds. Rebello (1924), studying the effect of thyroid on hyacinth bulbs, found an acceleration in growth when he used a powdered extract of the gland. Fresh thyroid seemed to have no effect on the growth of the bulbs. Buddington (1925) found that the root tips of *Narcissus* bulbs growing in Pfeffer's solution, to which had been added thyroid gland substance, showed a growth markedly abbreviated as compared with the controls. With the shorter length was associated differentiation of special root tissues nearer and nearer the root tip, and in all cases much nearer than in the controls. It was concluded that thyroid substances cause precocious differentiation in both plant and animal tissues. This was held to suggest that animal and plant protoplasms are near enough alike physiologically to respond similarly to the same endocrine substance. Hence, it is concluded that thyroid substances are influential in essentially the same manner on all protoplasm.

The work of Davis (1934) confirmed the findings of Buddington. Experiments were made in which *Allium* and *Narcissus* bulbs and *Vicia faba* plants were treated with injections of thyroid material, and seedlings of *Pisum sativum* were grown in solutions containing thyroxin. The time of flowering of *Allium* and *Narcissus* was hastened in the thyroid treated plants. *Allium* plants showed an average acceleration of 16 percent in time of flowering, and in height and number of flower stalks. Acceleration in the flowering time of *Narcissus* occurred also, but was not as marked as in *Allium*. In general, the green vegetative parts of the treated plants were depressed in growth, although they sometimes showed an early temporary acceleration. *Vicia faba* showed a depression in growth in 75 percent of the observations, and *Pisum* was depressed in 88 percent of the cases.

The above observations on the effect of thyroid on protoplasm in general point to several fundamental conclusions. First, the metabolic processes of vertebrate, invertebrate, and plant tissues are accelerated by the addition of thyroid substance to the culture medium, or by thyroxin injections prior to isolation of the tissues. Secondly, the accelerated metabolic processes of isolated tissues result in reactions similar to those in the living vertebrate organism. The acceleration in metabolism of isolated animal tissues due to thyroid treatment may result in either increased oxygen consumption or accelerated cell division or both. In the case of accelerated cell division, the dosage or concentration of thyroid is undoubtedly of a nature conducive to a predominance of anabolic over katabolic metabolism. In cases where cell division is retarded, there is still an increase in oxygen consumption, resulting from a predominance of katabolism. As was observed in the thyroid treatment of vertebrate organisms, the dosage is the factor which determines the predominant phase of metabolism in the isolated tissue.

The above facts point to no other logical conclusion than that thyroid extract or the isolated hormone, thyroxin, in association with isolated vertebrate, invertebrate, or plant tissues, cause an acceleration in one or the other, or both (anabolic and katabolic) processes of metabolism. In this respect the above-mentioned tissues may be considered as near enough alike physiologically to respond to the same endocrine substances. Hence, thyroid undoubtedly exerts its metabolic regulator activity on all protoplasm irrespective of the organism into which it is built.

THYROID FEEDING OF INVERTEBRATES

Other investigations which have added to our knowledge of the effects of thyroid substance on protoplasm in general have

been the studies on thyroid feeding of invertebrates. Up to the present time, no one to our knowledge has demonstrated the presence of an active thyroid gland in any invertebrate organism. A study of the effects of thyroid feeding on invertebrates is of prime importance then in determining whether or not organisms that do not naturally possess any thyroid structure will respond to the action of thyroid secretion. A knowledge of these effects should lead to some conclusion as to whether or not the thyroid is effective in the same physiological manner on organisms throughout the animal kingdom. The work concerning the thyroid feeding of invertebrates has been centered largely around the protozoa and insects.

The effect of thyroid feeding on protozoa was first studied by Nowikoff (1908), who observed that *Paramecia* fed with an extract of the vertebrate gland seemed to divide more rapidly than those kept in ordinary hay infusions. Nowikoff used Merck's Glandula thyroidea dissolved in distilled water, shaken and filtered several times through paper and finally diluted to a one or two percent solution. A number of *Paramecia* (1 to 3) were placed in a few drops of this extract on a slide; other individuals for controls were placed in a similar quantity of hay infusion medium. The cultures were kept in a moist chamber and observed daily. The observations indicated a larger number of individuals in the thyroid medium than in the hay infusion. Shumway (1914) criticized Nowikoff's method of experimentation, saying that the earlier worker had not made corrections for the toxic effects resulting from excretory products when a group of individuals is kept in the same medium for a number of days. Another source of error in Nowikoff's work was found in the fact that he made no attempt to secure closely related *Paramecia* for the experiment, the necessity for which is shown by the great variability in reaction and viability possessed by different races and individuals of this form. The experiments of Shumway (1914) were based on a pedigreed line of *Paramecium aurelia* during the life history of 420 generations. The medium in which the control line was kept was prepared by boiling one gram of hay in 100 cc. of tap water for 10 minutes, filtering and allowing it to stand for 24 hours, when it was mixed with an equal quantity of tap water. The experimental lines were treated with the regular control medium to which was added small quantities of thyroid or thymus material. No attempt was made to render the extracts absolutely bacteria-free. The individuals treated with thyroid were as a rule more active, and slightly smaller than the control individuals, and their protoplasm was more transparent. The thymus treated individuals, on the other hand, were more sluggish, larger, and darker than the controls. The conclusion was drawn that the lighter color and smaller size of the thyroid individuals were effects due to accelerated processes of metabolism (faster digestion, excretion, etc.), whereas the appearance of the thymus fed was due to the presence of undigested food granules. The experiments showed that thyroid extract greatly increased the rate of division of *Paramecium*, except at the time when the line was nearing the close of its cycle. This effect was not permanent, but disappeared when the thyroid feeding was stopped. Similar treatment with thymus extract gave no accelerating effect in the rate of division. The conclusion was drawn that thyroid directly affects the metabolic activities of the cell, hence leading to a faster rate of division. A very thorough study made later by the same worker (1917) substantiated his earlier work. It was shown that thyroid substance fed to *Paramecium aurelia* or *P. caudatum*, either as an emulsion of raw thy-

roid or as a suspension of the commercial powder, produced a constant and significant increase of 65 percent in the rate of division as compared with that characteristic of individuals grown in an ordinary hay infusion medium. It was noted further that the thyroid was the only one of the organs of internal secretion that produced this effect on *Paramecium*, and that boiling the extract had no effect on its potency. As in the earlier work, it was found that *Paramecia*, after prolonged thyroid feeding, revert to the normal rate of division when returned to the control diet.

TABLE 2

Division rate of Paramecium

Race A. Summary of experiments. Average division rate per day. (From Shumway, 1917. Jour. Exper. Zool., Vol. 22, pp. 529-563).

EXPERIMENT	CONTROL	THYROID	DAYS
I	1.40	2.80	35
II	1.65	3.10	15
III	2.65	3.20	5
IV	1.90	3.20	10
V	0.70	3.70	5
VI	2.00	2.55	10
VII	2.40	3.20	15
VIII	1.50	2.65	5
IX	0.70	0.85	20
Average....	1.60	2.65	120

Iodothyrin and iodine failed to produce the thyroid effect. Shumway's data are summarized in Table 2.

Buddington and Harvey (1915) determined the effects of the thyroid from a variety of vertebrates on the division rates of ciliate protozoa. Perfectly fresh glands were taken from the fresh water sucker (*Catostomus teres*), the frog (*Rana pipiens*), the turtle (*Cistudo carolina*), the chick (*Gallus domesticans*), and the cat, (*Felis domestica*), dried, powdered, and kept in closed containers until used. The forms used for experimentation were *Stylonichia* and *Paramecium*. Every one of the gland substances used produced an acceleration in cell division of the ciliates. The effect was small for the fish thyroid and progressively larger in ascending the phylogenetic scale to the cat, so that the average effect was something of the order of a 300 percent increase in rate of division. This led the writers to the conclusion that the physiological qualities of the thyroid glands of the phylogenetically "higher" and "lower" vertebrates are constant and similar in all. The findings reported in the above three mentioned papers have generally been cited as a corroboration of the view that the active principle of the thyroid directly accelerates metabolism.

In complete contradiction to the above conclusions are the findings of a group of later workers. Riddle and Torrey (1923), studying the effect of thyroxin on *Paramecium* reported a slight decrease in cell division and a large increase in excretory activity in the organisms living in a culture medium to which the crystalline hormone had been added. On the basis of 18 experiments, where observations were made for periods ranging from 7 to 71 days, the mean decrease in cell division in the thyroxin cultures was 4.54 percent. These authors emphasized the contrast between their observations and those of Shumway (where a large increase in cell division of *Paramecia* followed thyroid feeding) and suggested that factors in the thyroid other than thyroxin may have been responsible for Shumway's results. The acceleration in excretory processes in *Paramecia* was indicated by an increase in the number of accessory canals, and by a great decrease in the number of excretory crystals in the endoplasm. These investigators concluded that thyroxin promotes katabolism rather than anabolism, hence the slower division, and faster excretion of *Paramecia* when treated with the hormone. This

conclusion was also reached by Woodruff and Swingle (1923) who investigated the influence of thyroid products on protozoa by a series of experiments on a pedigreed race of *Paramecium*. The results showed in a clear cut manner that neither thyroxin (Squibb's) nor commercial desiccated thyroid, or fresh desiccated thyroid of the turtle produced any significant acceleration in the rate of division in *Paramecium*. These workers expressed the opinion that results to the contrary, published by previous investigators were attributable to variations in the bacterial food supply which the different media afforded the *Paramecia*. Accordingly they believed all the studies showing that thyroid products accelerate cell anabolism and consequent division to be erroneous.. Torrey (1923) repeated the experiments on thyroxin treatment of *Paramecium* mentioned above (Riddle and Torrey, 1923), and found the division rate of thyroxin lines to be only about one-third the rate exhibited by control lines. In this investigation, the experimental animals were raised in a medium containing 0.0001 percent thyroxin in N/5000 NaOH; the controls in the same medium less thyroxin. Later (1924) Torrey confirmed his earlier work on the effect of thyroxin on *Paramecium*, showing that the hormone depressed cell division independently of the food supply and hydrogen ion concentration of the medium. The conclusion was reached that the depressant action of thyroxin increased directly with the concentration but with decreasing increments.

Cori (1923) studied the effects of both thyroid and thyroxin on the division rate of *Paramecia* and reached some fundamental conclusions. Ordinary hay infusion was the medium used for the controls, while filtered thyroid solution in concentrations of 1:100, 1:200 and 1:300, and thyroxin solutions of 1:100,000 were added to the medium of the experimental animals. It was found that a faintly alkaline thyroid extract of 1:200 strongly accelerated the rate of cell division in *Paramecium putrinum*. An equivalent concentration of thyroxin (1:100,000) in hay infusion only slightly accelerated the rate of cell division. His data are summarized in the following tabulation:

Number of divisions in 24 hours averaged from 5 sister cultures in 5 days

For control	4.53	4.87	3.53	5.00	5.04
For thyroxin 1:100,000.....	4.72	5.00	—	4.95	5.22
For thyroid 1:100	—	—	3.91	5.40	5.70

The average ratio was control: thyroxin: thyroid = 100:102:112.

The suggestion was made that thyroid extract must contain some active principle other than thyroxin, which accelerates the division rate of *Paramecia*. If this were true some of the contradictions among earlier investigators would become reconciled.

The work of Cori was substantiated by the experiments of Torrey, Riddle, and Brodie (1925). These investigators found that thyroxin in concentrations ranging from 1:10,000 to 1:1,000,000, affected *Paramecia* the same as total thyroid in accelerating certain processes of metabolism, especially those concerned with excretion. However, thyroxin had an effect exactly opposed to that of thyroid on the rate of cell multiplication. Whereas the thyroid accelerated cell division, thyroxin depressed the division rate of *Paramecium* in a degree directly proportional to its concentration. The conclusion was reached that the decrease in rate of cell division in *Paramecium* was due to the action of thyroxin on the organisms themselves, and not to changes in food supply.

The observations of Torrey (1928) on thyroxin treatment of the fertilized egg of

several invertebrates are entirely in accord with those of Cori and others on thyroxin treatment of *Paramecium* mentioned above. Eggs from the sea-urchin, *Echinometra lucunter*, and the ascidian *Phallusia nigra* were fertilized and kept in sea water containing thyroxin in concentrations varying from 1:50,000 to 1:1,600,000. The heavier concentrations completely inhibited the cleavage of the majority of eggs of *Echinometra*, and hastened their disintegration. In the lighter concentrations a similar effect was observed, though decreasing as the concentration decreased. With *Phallusia*, the results were somewhat similar to those obtained for *Echinometra*. In the heavier concentrations, cleavage began later and involved fewer eggs, gastrulation occurred later, and the larvae 5.5 hours after fertilization were inferior both in number and in development as compared with controls. In the lighter concentrations, the effect was less drastic, though even in the dilution of 1:1,000,000 there was a general retardation of about 10 percent in development. In the light of studies on the effect of thyroxin on division rate of Protozoa the above results obtained by Torrey do not present any great difficulty. In the Protozoa, it was noted that whereas thyroid extract accelerated total metabolism (anabolism and katabolism) the isolated hormone, thyroxin, accelerated only the katabolic processes. An accelerated rate of katabolism was in all probability responsible for the retarded division rate of Torrey's invertebrate eggs treated with thyroxin. It is of interest here to note the similarity in reaction of a phylogenetically 'low' organism (Protozoa) and the immature stages of phylogenetically 'higher' organisms (*Echinometra* and *Phallusia*). On the basis of the recapitulation theory, the sea-urchin and the ascidian at some early age pass through a stage in development which is physiologically if not anatomically similar to the Protozoa. The similarity in reaction of the 2-to-8 cell stages of *Echinometra* and *Phallusia* to that of *Paramecium*, insofar as thyroxin is concerned, would seem to bear out this point beautifully. Butler (1928) confirmed Torrey's conclusions in a report on the effect of various concentrations of thyroxin on the cleavage rate of Arbacia eggs. Thyroxin in sea water in a concentration of 1:50,000 retarded the first cleavage of the eggs of *Arbacia punctulata* by about 5 minutes. This retardation persisted through all the later cleavage stages. A concentration of 1:100,000 produced a retardation in cleavage, though to a lesser degree than the first dosage. In a concentration of 1:25,000 retardation in the rate of division was about twice that produced by the 1:50,000 solution.

Susaeta (1930) also confirmed the work of Torrey, and further substantiated the observations on the differential effects of thyroid and thyroxin on lower invertebrate organisms. In this study, the cleavage stages of the Pholadid mollusk *Barnea candida* were subjected to several concentrations of synthetic thyroxin and thyroid extract. Thyroxin, in all concentrations showed a retarding influence on the rate of development of this form. Up to concentrations of 5 cc. per liter, the thyroid produced a slight acceleration; above that dosage there was a variable retardation. The 2-and-4-cell stages were especially susceptible in all cases. The retarding effect of thyroxin in this case may well have been explained in terms of accelerated katabolism, while the thyroid effect was undoubtedly due to an acceleration of total metabolism.

From the above investigations it is evident that thyroid extract and the isolated hormone, thyroxin, affect the metabolic processes in the single cell of *Paramecium*,

and in the early cleavage stages of other invertebrates. Thyroid apparently accelerates both anabolism and katabolism, resulting in an increased rate of cell division and excretion. Thyroxin, on the other hand, seems to affect only the katabolic processes in the cell, hence the accelerated rate of excretion and the slightly depressed rate of cell division.

The effect of thyroid feeding on insects has been studied by several workers. Kunkel (1918) found that feeding the larvae of *Lucilia caesar*, *L. sericata* and *Calliphora erythrocephala* exclusively upon mammalian thyroid tended to retard slightly the growth of the larvae, and consequently to reduce the size of the resulting pupae, as compared with the muscle- or thymus-fed controls. His studies showed also that thyroid tended to hasten the onset of pupation (shorten the larval period) and shorten the period of pupation. This worker noted that the hastened development and retarded growth caused by thyroid feeding were similar to the effects of thyroid feeding on vertebrates, though not nearly so marked.

Romeis and von Dobkiewicz (1920) working with thyroid-fed larvae of *Calliphora vomitoria* obtained results directly opposite to those of Kunkel. Whereas Kunkel obtained accelerated metamorphosis, these investigators observed that their thyroid animals were retarded from 25 to 35 hours throughout the entire period of metamorphosis as compared with the muscle-fed controls. The thyroid-fed animals, during the early stage of larval development, were smaller than the controls, but this difference had disappeared by the time pupation occurred. In fact, the thyroid-fed pupae were slightly heavier than the controls, and the adults of the experimental group appeared to be "better fed" than the controls.

The inconsistency of results reported in the above two papers is undoubtedly an expression of differences in experimental technique rather than of any real difference in the effect of thyroid gland feeding. The gland substance in each case was that of the calf, and the method of feeding in each was to allow the larvae to live in the tissue substance. Romeis and von Dobkiewicz used isolated larvae, necessitating the mechanical control of the moisture in the food medium (especially thyroid) and a change of the food every few days to prevent putrifaction. The resulting "better fed" adults, obtained by Romeis and von Dobkiewicz by thyroid feeding may have been due to the frequent change in food supply, since it was noted that it was necessary to renew the thyroid more often than the muscle (control) substance.

Reznitchenko (1926), studying the effect of thyroid feeding on *Drosophila melanogaster*, found that no changes were produced in the length of either larval or pupal period when the concentration of thyroid was less than 5 percent of the total ration. In concentrations of 10 percent thyroid substance there was a slight retardation in development. This latter effect was considered as a toxic reaction, rather than any specific hormonal effect. Later (1927) this same investigator confirmed his earlier work on thyroid feeding of *Drosophila* by showing that thyroidin added to a diet of potato and yeast produced no effects on the rate of development of this form. From the experience of these two studies the author concluded that thyroid was non-specific for invertebrates. In contrast to the findings of Reznitchenko are those of Alpatov (1929). In this study, the extract used was powdered hog thyroid containing 0.42 percent of iodine. It was fed to the Drosophila by mixing it with yeast in the proportion of 0.05 gm. thyroid to 0.50 gm. yeast; this mixture then being mixed with distilled water and

added to the food bottles at the rate of 5 drops per day during the larval period. The food bottles contained 50 gm. of plain 2 percent agar-agar. The controls were fed powdered hog muscle in the same proportion that the experimentals were fed thyroid. For the first 48 hours of the experiment, the bottles were kept at a temperature of 30°C. and thereafter at 28°C. Larvae 0–4 hours old were placed on the food, and 67 hours later they were killed and measured. Nine experiments including a total of 8000 flies were thus measured. All the experiments showed definitely that the thyroid larvae killed just before they started to leave the food and crawl up the sides of the bottle were significantly larger than the controls. The data from a representative experiment are given in Table 3.

TABLE 3

Larval growth of Drosophila

All larvae belonging to the third stage. Initial density, 80 larvae per bottle. (From Alpatov, W. W. 1929. Proc. Nat. Acad. Sci., Vol. 15, pp. 578–580.)

	MEAN LENGTH (IN MM.)	STANDARD DEVIATION	COEFFICIENT OF VARIATION	N	DIFFERENCE	DIFF. / P.E. DIFF.
Control.....	4.916 ± 0.007	0.1210	4.31 ± 0.10	400	0.222 ± 0.010	22.2
Thyroid.....	5.138 ± 0.007	0.1266	4.41 ± 0.10	422		

The experiments in which the flies were allowed to reach maturity showed that the thyroid-fed adults were slightly smaller than the controls. These results indicated to the author that thyroid feeding had an accelerating effect only during larval development and that this fact, coupled with the fact that the experimental adults were smaller than the controls, confirmed the work of many authors on the thyroid feeding of amphibia. The conclusion was reached that substances produced by the glands of internal secretion have a universal effect on living organisms. It will be noted that Alpatov was the first to make a careful study of the problem from a statistical point of view, and that in this respect, his findings are of greater significance than those based on random judgment of the characters affected. The data of Alpatov are far more reliable than those of Reznitchenko, because the later investigator made no attempt to correct for differences in fly density, which, as he stated, seemed to affect rate of development more than any other factor. There was a 10 percent variation in each 24-hour observation of several control groups, so that the differences exhibited by the experimentals seemed only a natural occurrence.

Later Koller (1932) made a study of the effect of chemically pure thyroxin on certain characteristics of *Drosophila melanogaster*. This worker found that thyroxin had no effect on rate of metamorphosis, fecundity, sex ratio, size, or crossing-over in this form. A slight delay in egg-laying was attributed to a secondary action of the thyroxin (higher pH in the food medium). From the variations in the results of thyroid treatment of *Drosophila*, it is evident that much more carefully controlled experimentation is required to make a conclusive statement about the problem.

The work of Comas (1928) indicated that thyroid feeding of the larvae of *Chironomus thummi* K. caused an acceleration in larval growth, especially during the mid-period of development. Concomitant with the accelerated develop-

ment came an increase in size attained by the animals. Zavřel (1930) found that young or medium, later summer or fall larvae of *Chironomus clavaticrus* K. fed dried thyroid grew more rapidly than the controls, especially at the beginning of the experiment, but did not metamorphose any faster than the controls. Early summer larvae fed with thyroid extract grew very rapidly and metamorphosed 1 to 2 months earlier than the controls. The embryo development of fresh laid eggs was greatly delayed by thyroid extract, but when the eggs were returned to fresh water the embryos soon recovered from the effect and continued developing normally. The growth of larvae from thyroid treated eggs sometimes surpassed that of the controls. Muscle extracts had no stimulating effect on the midge larvae.

From these studies it is evident that, for *Chironomus* at least, the age of the larvae as well as the seasonal form must be taken into consideration in dealing with the problem. Generally speaking, thyroid extract produces an acceleration in the early growth of all larval forms, but the effect on metamorphosis and final size depends on the particular seasonal form studied.

Abderhalden (1919) observed that thyroid feeding had no noticeable effect on the rate of development of the moth, *Deilphila euphorbia*, but that the pupae and adult forms were much smaller than those fed with thymus extract. This worker stated that the extent of variations in his results made it impossible to give a final conclusion until further experimental work showed more constant effects. Romeis and von Dobkiewicz (1920) noted that their work on *Calliphora* was at variance with that of Abderhalden, but they considered that the difference in the forms used in the two experiments, together with Abderhalden's variable and inconclusive results easily accounted for all discrepancies.

Romeis and von Dobkiewicz (1932) and Romeis and Wüst (1932) noted that the pupae of *Papilio podalirius*, *Vanessa io*, or *Vanessa atalanta* showed little or no rise in metabolism following sterile injections of thyroxin. The hormone had no observable effect on the growth or metamorphosis of these forms.

Kopeć (1924) reported a thyroid feeding experiment on the caterpillars of *Lymantria dispar* L. The newly hatched larvae were fed on willow leaves sprayed with water (control), and on the same type of leaves sprayed with a thyroidin suspension in water. Two to four "tablettae thyreoideae" were used daily, though this gives us no indication of the relative or absolute quantity of thyroid in the total ration. The total number of thyroid chrysalids was 422; of controls 396. It was observed that the thyroid extract did not cause any distinct changes in the duration of larval or pupal periods. The only effect noted was a diminution of weight in the thyroid-fed chrysalids, as compared with controls. These results are similar to those obtained by Abderhalden (above), with *Deilphila euphorbia*, and furthermore are based on a statistical study of the data. The conclusions, however, cannot be taken too seriously until the work is confirmed by check experiments, in which *known* quantities of thyroid are fed, and until the effects of widely varying concentrations of the extract on the organisms have been determined.

Fleischmann (1929) studied the effect of parenteral injections of a 1:10,000 concentration of thyroxin solution on the larvae of *Lymantria dispar*. The controls were injected with equal quantities of a normal salt solution, and some were left uninjected. No effect was observed in the length of larval or pupal period of the

experimental animals as compared with the controls. Further, there were no differences in either weight, color, or pattern among the experimental and control groups. These findings were based on the performances of 61 experimental and 44 control animals, and were cited as confirming the work of Romeis (*et al.*) noted above.

Terao and Wakamori (1924) criticized the work of Abderhalden (1919) and Romeis and von Dobkiewicz (1920) by suggesting that the negative results of the latter two investigations were due to the fact that the observations were based on the first generation only, and that if the observations had been carried to a second generation, certain effects may have been noted. In the experiments of Terao and Wakamori (1931), larvae of the silk-worm *Bombyx mori* L. were fed on mulberry leaves over which had been sprinkled a commercial thyroid powder. The thyroid varied from 1/50 to 1/400 of the weight of the food. It was noted that the experimental animals did not eat their food as readily as the controls, possibly because of an unpleasant odor or taste of the thyroid substance. Throughout the entire life, there was no acceleration observed in the rate of development as a result of thyroid feeding. On the contrary, the more of the gland substance fed, the slower the animals developed. The adults of the experimental group were smaller than the controls, and generally in indirect proportion to the quantity of the thyroid given. In a second generation experiment, larvae hatched from the eggs of those parents which had, as larvae, been fed thyroid extract were reared together with the second generation of the control under the same (control) conditions. From the beginning of the larval period to the end of the third instar, both groups behaved the same so far as the speed of metamorphosis was concerned. From the fourth instar on, the progeny of the thyroid-fed parents passed through their developmental stages considerably earlier than the control progeny, the average difference being 12 hours at the commencement of moulting, and 24 hours at the end of the pupal period. The experimental progeny were smaller than the controls when hatched because they came from smaller eggs laid by the thyroid-fed animals. This difference, however, decreased as development proceeded, and at the end of the second instar, the opposite was the case, i.e., the experimental progeny were larger than the controls. The experimental group kept supremacy over the controls in size until the beginning of the fifth instar, when the former became abruptly smaller than the latter. Consequently the resulting pupae, cocoons, and adults of the experimental progeny were smaller than the controls. In spite of the smaller size, however, they laid more eggs and produced more silk than the controls. Later (1931) these investigators confirmed their earlier work on the second generation effect of thyroid feeding on *Bombyx*, and concluded that the action of the thyroid would, in time, be shown throughout the animal kingdom, and that the gland substance would be shown to be specific only in its degree of activity in the different forms.

Kahn (1921) studied the effects of thyroid feeding on the larvae of *Corethra plumicornis*, *Ecdyurus forcipula*, and *Tenebrio molitor*. Other than a change in the color of the pupae (lighter than controls) no effect of thyroid feeding was observed in these forms. The rates of metamorphosis and growth were identical in the control and experimental groups. The conclusion was reached that the changes in growth and development of vertebrates due to thyroid feeding do not appear in the inverte-

brates because they are not affected by the vertebrate hormone. A conclusion very similar to this was reached by Hahn (1929) based on his experiments with *Vanessa io* and *Tenebrio molitor*. The larvae of *Vanessa* were fed on nettle leaves sprinkled with thyroid extract. The controls were fed on similar leaves sprinkled with an extract of ox heart. There was a slight diminution in the rate of development of the thyroid-fed animals, with a slight increase in body weight. These differences were so small they were not considered due to any specific thyroid effect. For *Tenebrio* no effect at all was observed in rate of development or growth as a result of feeding a concentration of 1 part thyroid to 3 parts meal. The experimental animals compared favorably with the controls (extract of ox heart in meal), in color, sexual development, and sex ratio. Here again the conclusion was made that thyroid is non-specific for invertebrates.

SUMMARY

It is clear that invertebrate organisms (Protozoa and insects, at least) although not possessing any thyroid structure, will, in some cases, respond to the action of the thyroid hormone. Further it is evident that, when there is a response, the reaction is quite similar to that seen in vertebrates; an increased rate of metabolic processes. The abundance of negative results reported above, however, puts us in no better position than was Koller (1929) when he said "The feeding of invertebrate animals with vertebrate hormones has not yet led to definite and unambiguous conclusions."

One obvious reason for the indefinite and ambiguous conclusions, as mentioned previously, is that no systematic attempt has been made up to the present to determine the influence of a logically planned series of concentrations of thyroid substance on an invertebrate organism. From the literature, it is difficult to determine the exact dosage, either absolute or relative to the total ration, that was fed in the great majority of experiments that have been reported. Further, it is evident that in most cases only one or at most a very few different concentrations were used. If a variety of concentrations had been used, and careful statistical comparisons had been made, many of the negative results obtained by earlier investigators, working with only *one* concentration, would undoubtedly have been found to be due to the toxic effect of too heavy a concentration, or to the lack of effect from too light a concentration. In investigations such as those reviewed it is essential to determine at least (1) the optimal concentration for any particular effect; (2) the minimal concentration for producing any effect at all, and if possible (3) the lethal concentration.

Another question that needs considerable experimental evidence for its solution is that of the possible transfer of the thyroid effect to a second generation without thyroid feeding. This phenomenon has been asserted and denied in the literature, though with none too conclusive evidence on either side.

An account of the experimental work by which the writer has attempted to solve some of the above questions will appear in a later publication.

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LIST OF LITERATURE

ABDERHALDEN, E. 1915. Studien über die von einzelnen Organen hervorgebrachten Substanzen mit spezifischer Wirkung. I. Mitteilung. Verbindungen die einen Einfluss auf die Entwicklung und den Zustand bestimmter Gewebe ausüben. *Pflüg. Arch. f. Physiol.*, Bd. 162, pp. 99–118.

——. 1919. Weitere Studien über die von einzelnen Organen hervorgebrachten Substanzen mit spezifischer Wirkung. II. Mitteilung. *Pflüg. Arch. f. Physiol.*, Bd. 176, pp. 236–262.

——, and O. Schiffmann. 1922. Studien über die von einzelnen Organen hervorgebrachten Substanzen mit spezifischer Wirkung. VIII. Mitteilung. *Pflüg. Arch. f. Physiol.*, Bd. 195, pp. 167–198.

A[llen], B. M. 1916. The results of extirpation of the anterior lobe of the hypophysis and of the thyroid of *Rana pipiens* larvæ. *Science*, Vol. 44, pp. 755–757.

——. 1918. The results of thyroid removal in the larvæ of *Rana pipiens*. *Jour. Exper. Zool.*, Vol. 24, pp. 499–519.

——. 1932. The response of *Bufo* larvæ to different concentrations of thyroxin. *Anat. Rec.*, Vol. 54, pp. 45–64.

Alpatov, W. W. 1929. The influence of the thyroid gland feeding on the acceleration of the growth of larvae of *Drosophila melanogaster*. *Proc. Nat. Acad. Sci.*, Vol. 15, pp. 578–580.

Alphonse, P., and G. Baumann. 1935. L'action de la thyroxine sur les têtards de batraciens anoures dépend-elle de la durée du séjour dans les solutions? *Compt. rend. Soc. Biol., Paris*, T. 119, pp. 1243–1245.

Ashbel, R. 1935. Action of thyroid extract on the respiration of tissues of invertebrates. *Nature*, Vol. 135 p. 343.

Asmundson, V. S., and P. Pinsky. 1935. The effect of the thyroid on the formation of the hen's egg. *Poultry Sci.*, Vol. 14, pp. 99–104.

Aub, J. C. 1927. Relation of thyroid to calcium metabolism. *Trans. Assn. Phys., Abstract, Jour. Amer. Med. Assn.*, Vol. 89, p. 149.

Ball, James M. 1910. Andreas Vesalius, the Reformer of Anatomy. *St. Louis* (Med. Sci. Press).

Balthasart, M. 1932. La métamorphose expérimentale des amphibiens. *Ann. Soc. Roy. Zool. Belgique*, T. 62, pp. 79–114.

Basedow, C. A. 1840. *Wchnschr. f. d. ges. Heilk., Berlin*, Bd. 6, pp. 197, 220. [Quoted from Garrison (1917).]

Baumann, E. 1896. Ueber das normale Vorkommen von Jod im Thierkörper. *Zeitschr. f. physiol. Chem.*, Bd. 21, pp. 319–330.

Bělehrádek, J., and J. S. Huxley. 1927. Changes in oxygen consumption during metamorphosis induced by thyroid administration in the axolotl. *Jour. Physiol.*, Vol. 64, pp. 267–278.

Bernard, Claude. 1855. Leçons de Physiologie experimentale. T. 1 and 2, p. 96 of Les Oeuvres . . . *Paris.*

——. 1859. Leçons sur les Propriétés physiologiques et les Altérations pathologiques des Liquides de l'Organisme. T. 6 and 7, pp. 411–412 of Les Oeuvres . . . *Paris.*

Binswanger, F. 1936. Studien zur Physiologie der Schilddrüse. III. Schilddrüse und Wachstum (Studien am Hund). *Endokrinologie*, Bd. 17, pp. 150–161.

Blalock, A., and T. R. Harrison. 1927. The effects of thyroidectomy and thyroid feeding on the cardiac output. *Surg., Gynec. and Obst.*, Vol. 44, pp. 617–626.

Brambell, F. W. R. 1926. The influence of thyroid gland on the plumage of the fowl. *Proc. Roy. Irish Acad.*, Vol. B 37, pp. 117–124.

Brown, W. T., and E. F. Gildea. 1937. Hyperthyroidism and personality. *Amer. Jour. Psychiat.*, Vol. 94, pp. 59–76.

Buddington, R. A. 1919. The influence of certain ductless gland substances on the growth of plant tissues. *Biol. Bull.*, Vol. 37, pp. 188–193.

——. 1925. A suggestion as to the effect of thyroid gland substances on protoplasm in general. *Biol. Bull.*, Vol. 48, pp. 83–91.

——, and H. F. Harvey. 1915. Division rate in ciliate Protozoa as influenced by thyroid constituents. *Biol. Bull.*, Vol. 28, pp. 304–314.

Butler, E. G. 1928. The thyroid and the rate of cell division. *Proc. Soc. Exper. Biol. and Med.*, Vol 26, pp. 231–233.

Carlson, A. J., J. R. Rooks, and J. F. McKie. 1912. Attempts to produce experimental hyperthyroidism in mammals and birds. *Amer. Jour. Physiol.*, Vol. 30, pp. 129–159.

Carrel, A. 1913. Artificial activation of the growth in vitro of connective tissue. *Jour. Exper. Med.*, Vol. 17, pp. 14–19.

Champy, C. 1922. L'Action de l'Extrait thyroïdien sur la Multiplication cellulaire; Caractère électif de cette Action. *Arch. de Morphol. gén. et expér.*, No. 4, pp. 58.

——, and J. Morita. 1929. Déterminisme thyroïdien de la poussée du plumage adulte chez les poulets. *Compt. rend. Soc. Biol.*, Paris, T. 99, pp. 1116–1118.

Chang, H. C. 1926. Specific influence of the thyroid gland on hair growth. *Amer. Jour. Physiol.*, Vol. 77, pp. 562–567.

Cockayne, E. A. 1918. The influence of heredity in exophthalmic goitre. *Arch. Dis. Child.*, Vol. 3, pp. 227–231.

Coindet, J. R. 1820. Decouvre de la Rémedie contre le Goitre. Bibl. Universelle de Genève. Translation by Johnson, 1924. [Quoted from Harington, 1933.]

Cole, L. J., and F. B. Hutt. 1918. Further experiments in feeding thyroid to fowls. *Poultry Sci.*, Vol. 7, pp. 60–66.

——, and D. H. Reid. 1924. The effect of feeding thyroid on the plumage of the fowl. *Jour. Agric. Res.*, Vol. 29, pp. 285–287, + 1 pl.

Comas, M. 1928. Sobre la influencia de la tiroidina en el desarrollo de *Chironomus thummi*, K. *Biol. Soc. Espan. Hist. Nat.*, T. 28, pp. 309–314.

Cori, G. T. 1923. The influence of thyroid extracts and thyroxin on the rate of multiplication of *Paramecia*. *Amer. Jour. Physiol.*, Vol. 65, pp. 295–299.

Crew, F. A. E. 1925. Rejuvenation of the aged fowl through thyroid medication. *Proc. Roy. Soc. Edin.*, Vol. 45, Part III, pp. 252–260.

Cunningham, R. H. 1898. Experimental thyroidism. *Jour. Exper. Med.*, Vol. 3, pp. 147–243 + 5 pl.

Curling, T. B. 1850. Two cases of absence of the thyroid body and symmetric swellings of fat tissue at the sides of the neck, connected with defective cerebral development. *Med. Chir. Trans.*, Vol. 33, pp. 303–306.

Da Costa, E., and A. J. Carlson. 1933. The effect of feeding desiccated thyroid upon the sexual maturation of the albino rat. *Amer. Jour. Physiol.*, Vol. 104, pp. 247–252.

Davis, E. E. 1934. Influence of thyroxin on the growth of plants. *Plant Physiol.*, Vol. 9, pp. 377–384.

Davis, J. E., Esther Da Costa, and A. Baird Hastings. 1934. The effect of thyroxin on the tissue metabolism of excised frog heart. *Amer. Jour. Physiol.*, Vol. 110, pp. 187–190.

Domm, L. V. 1929. Some effects of hyperthyroidism in the Brown Leghorn fowl. *Abstract, Anat. Rec.*, Vol. 44, pp. 227–228.

Du Bois, E. F. 1916. The respiration calorimeter in clinical medicine. *Amer. Jour. Med. Sci.*, Vol. 151, pp. 781–799.

Durrant, E. P. 1928. Effect of desiccated thyroid feeding on growth of the guinea pig. *Amer. Jour. Physiol.*, Vol. 85, p. 364.

Dye, J. A. 1933. The action of thyroxin on tissue respiration. *Amer. Jour. Physiol.*, Vol. 105, pp. 518–524.

Eberling, A. H. 1924. Action de l'épithélium thyroïdien en culture pure sur la croissance des fibroblastes. *Compt. rend. Soc. Biol., Paris*, Vol. 90, pp. 1449–1450.

Fagge, C. H. 1871. Sporadic cretinism occurring in England. *Med. Chir. Trans.*, Vol. 54, pp. 155–170 + 1 pl.

Fishburne, M., and B. Cunningham. 1938. Replacement therapy in thyroidectomized rats. *Endocrinology*, Vol. 22, p. 122.

Fleischmann, W. 1929. Zur Frage der Beeinflussung Wirbelloser durch Wirbeltierinkrete. *Pflüg. Arch. f. Physiol.*, Bd. 221, pp. 591–593.

Folley, S. J., and P. White. 1936. The effect of thyroxine on milk secretion and on the phosphatase of the blood and milk of the lactating cow. *Proc. Roy. Soc., London*, Vol. B, 120, pp. 346–365.

Formey, M. 1823. Quelques observations sur le goître. *Arch. Gén. de Méd.*, Vol. 1, pp. 280–281.

Fox, E. L. 1892. A case of myxœdema treated by taking extracts of thyroid by the mouth. *Brit. Med. Jour.*, Vol. 2 for 1892, p. 941.

Gaddum, J. H. 1927. Quantitative observations on thyroxine and allied substances. I. The use of tadpoles. *Jour. Physiol.*, Vol. 64, pp. 246–254.

Galenus. 1854. Oeuvres Anatomiques, Physiologiques, et Medicales. Traduites par Dr. Ch. Daremberg. *Paris*. T. 1, pp. 510–511.

Garrison, F. H. 1917. An introduction to the History of Medicine. Second Ed. *Philadelphia* and *London* (W. B. Saunders Co.).

Gerard, R. W., and M. McIntyre. 1932. The effect of thyroid feeding on tissue respiration. *Amer. Jour. Physiol.*, Vol. 103, pp. 225–231.

Gericke, A. M. 1934. The thyroid and other endocrine glands in relation with plumage colour in fowls. *South African Jour. Sci.*, Vol. 31, pp. 415–424.

Gesell, A., C. S. Amatruda, and C. S. Culotta. 1936. The effect of thyroid therapy on the mental and physical growth of cretinous infants. *Amer. Jour. Dis. Child.*, Vol. 52, pp. 1117–1138.

Giacomini, E. 1926. Ulteriori osservazioni sulla metamorfosi degli axolotl; effetto della somministrazione di glandola tiroidea. *Rend. Sess. R. Accad. Sci. Ist. Bologna, Cl. Sci. Fis.*, T. 30, pp. 114–133.

——, and A. Taibell. 1927a. Gli effetti della tiroide sulla muta e sulla deposizione delle galline. *Rend. Sess. R. Accad. Sci. Ist. Bologna, Cl. Sci. Fis.*, T. 31, pp. 78–81.

——, and ——. 1927b. Sulle modificazioni del piumaggio causate nei polli ipertiroidizzati. *Rend. Sess. R. Accad. Sci. Ist. Bologna, Cl. Sci. Fis.*, T. 31, pp. 81–100.

——, and ——. 1927c. Gli effetti della tiroide sulla muta e sulla deposizione delle galline. *Boll. Soc. Ital. Biol. Sperim.*, T. 2, pp. 459–463.

——, and ——. 1927d. Sulle modificazioni del piumaggio causate dalla tiroide. *Boll. Soc. Ital. Sperim.*, T. 2, pp. 464–468.

Graham, W. R., Jr. 1934a. The effect of thy-

roidectomy and thyroid feeding on the milk secretion and milk fat production of cows. *Jour. Nutrition*, Vol. 7, pp. 407–429.

——. 1934b. The action of thyroxine on the milk and milk-fat production of cows. *Biochem. Jour.*, Vol. 28, pp. 1368–1371.

GRAVES, R. J. 1842. Clinical Lectures. Second American Edition. *Philadelphia* (E. Barrington and G. D. Haswell) and *New York* (J. and H. G. Langley). Pp. 151–152.

GUDERNATSCH, J. F. 1913a. Feeding experiments on tadpoles. I. The influence of specific organs given as food on growth and differentiation. A contribution to the knowledge of organs with internal secretion. *Roux' Arch. f. Entwicklungsmech.*, Bd. 35, pp. 457–501.

——. 1913b. Feeding experiments on tadpoles. II. A further contribution to the knowledge of organs with internal secretion. *Amer. Jour. Anat.*, Vol. 15, pp. 431–480.

——. 1915. Feeding experiments on rats. III. A further contribution to the knowledge of organs with an internal secretion. *Amer. Jour. Physiol.*, Vol. 36, pp. 370–379.

GULL, *Sir* W. M. 1874. On a cretinoid state supervening in adult life in women. *Trans. Clin. Soc., London*, Vol. 7, pp. 180–185.

GUNTHORP, H. 1932. Results of feeding thyroid glands of various types of vertebrates to tadpoles. *Physiol. Zool.*, Vol. 5, pp. 397–418 + 3 pl.

HADDEN, W. B. 1882. The nervous symptoms of myxœdema. *Brain*, Vol. 5, pp. 188–196.

HAHN, J. 1929. Über den Einfluss von Schilddrüsenfütterung auf die Metamorphose der Vanessa io und Tenebrio molitor. *Roux' Arch. f. Entwicklungsmech.*, Bd. 115, pp. 336–359.

HAMMETT, F. S. 1923. Studies of the thyroid apparatus. IX. The effects of the loss of the thyroid and parathyroid glands at 100 days of age on the growth in body length, body weight and tail length of male and female albino rats. *Amer. Jour. Physiol.*, Vol. 63, pp. 218–244.

——. 1924. Studies of the thyroid apparatus. XXVI. Correlation between thyroid weight and body weight. *Amer. Jour. Physiol.*, Vol. 69, pp. 510–517.

——. 1926. Studies of the thyroid apparatus. XXXIII. The rôle of the thyroid apparatus in the growth of the reproductive system. *Amer. Jour. Physiol.*, Vol. 77, pp. 527–547.

——. 1927a. Studies of the thyroid apparatus. XXXIX. The rôle of the thyroid and parathyroid glands in the growth of the heart and lungs. *Amer. Jour. Anat.*, Vol. 39, pp. 219–238.

——. 1927b. Studies of the thyroid apparatus. XL. The rôle of the thyroid apparatus in the growth of the liver, kidneys, and spleen. *Amer. Jour. Anat.*, Vol. 39, pp. 239–266.

——. 1929. Thyroid and growth. QUART. REV. BIOL., Vol. 4, pp. 353–372.

HARDESTY, M. 1935. The effect of thyroxin injections upon the feather of the guinea fowl. *Jour. Exper. Zool.*, Vol. 71, pp. 389–419.

HARINGTON, C. R. 1926. Chemistry of thyroxine. I. Isolation of thyroxine from the thyroid gland. *Biochem. Jour.*, Vol. 20, pp. 293–299.

——. 1933. The Thyroid Gland. Its Chemistry and Physiology. *London* (Oxford University Press).

——, and GEORGE BARGER. 1926. Chemistry of thyroxine. III. Constitution and synthesis of thyroxine. *Biochem. Jour.*, Vol. 21, pp. 169–183.

HELFF, O. M. 1926. Studies on amphibian metamorphosis. II. The oxygen consumption of tadpoles undergoing precocious metamorphosis following treatment with thyroid and diiodotyrosine. *Jour. Exper. Zool.*, Vol. 45, pp. 69–93.

HEWITT, J. A. 1919. The effect of administration of small amounts of thyroid gland on the size and weight of certain organs in the male white rat. *Jour. Exper. Physiol.*, Vol. 12, pp. 347–354.

HICKS, C. S. 1932. The influence of thyroxin administration and of thyroidectomy on the respiration of isolated muscle tissue. *Austral. Jour. Exper. Biol. and Med. Sci.*, Vol. 10, pp. 113–117.

HOPPING, A. 1931. Action of thyroxin on tissue metabolism. *Proc. Soc. Exper. Biol. and Med.*, Vol. 28, pp. 716–718.

HORNING, B., and H. B. TORREY. 1923. Effect of thyroid feeding on the color and form of the feather of fowls. *Anat. Rec.*, Vol. 24, pp. 395–396.

HOSKINS, E. R., and M. M. HOSKINS. 1917. On thyroidectomy in amphibia. *Anat. Rec.*, Vol. 11, p. 363.

——, and ——. 1919. Growth and development of amphibia as affected by thyroidectomy. *Jour. Exper. Zool.*, Vol. 29, pp. 1–69.

HUXLEY, J. S. 1910. Metamorphosis of axolotl caused by thyroid-feeding. *Nature*, Vol. 104, p. 435.

IMSHENETSKII, A. A. 1932. The influence of hormones on yeast, molds and bacteria. *Bull. Acad. Sci. U.R.S.S., Cl. Sci. Math. et Nat.*, T. 10, pp. 1559–1578. [In Russian with English summary.]

INGRAM, W. R. 1929. Studies on amphibian ne-

oteny. I. The metamorphosis of the Colorado axolotl by injection of inorganic iodine. *Physiol. Zool.*, Vol. 2, pp. 149–156.

KAHN, R. H. 1916. Zur Frage der Wirkung von Schilddrüse und Thymus auf Froschlarven. *Pflüg. Arch. f. Physiol.*, Bd. 163, pp. 384–404.

——. 1921. Über Schilddrüsenfütterung an Wirbellosen. *Pflüg. Arch. f. Physiol.*, Bd. 192, pp. 81–92.

KENDALL, E. C. 1915. The isolation in crystalline form of the compound containing iodin which occurs in the thyroid, its chemical nature and physiological activity. *Trans. Assoc. Amer. Physicians*, Vol. 30, pp. 420–449.

——. 1916. The active constituent of the thyroid: its isolation, chemical nature, and physiologic action. *Collected Papers of the Mayo Clinic*, Vol. 8, pp. 513–527.

——. 1919. Isolation of iodine compound which occurs in the thyroid. *Jour. Biol. Chem.*, Vol. 39, pp. 125–147.

——, and A. E. OSTERBERG. 1919. The chemical identification of thyroxin. *Jour. Biol. Chem.*, Vol. 40, pp. 265–334.

KOCHER, T. 1878. *Cor.-Bl. f. Schweiz. Aerzte, Basel*, Bd. 8, pp. 702–705. [Quoted from Garrison (1917)].

——. 1883. Über Kropfectirpation und ihre Folgen. *Arch. f. klin. Chir.*, Bd. 29, pp. 254–337.

KOLLER, P. C. 1932. Der Einfluss chemisch reinen Thyroxins auf die Entwicklung von *Drosophila melanogaster*. *Roux' Arch. f. Entwicklungsmech.*, Bd. 125, pp. 663–672.

KOLLER, V. G. 1929. Die innere Sekretion bei wirbellosen Tieren. *Biol. Rev.*, Vol. 4, pp. 269–306.

KOLLMANN, M. 1919. Quelques précisions sur l'accélération de la métamorphose des batraciens anoures sous l'influence de l'extrait de thyroïde. *Compt. rend. Soc. Biol., Paris*, T. 82, pp. 1009–1012.

KOPEĆ, STEFAN. 1914. Experiments on the influence of the thyroid gland on metamorphosis and weight of insects. *Mémoires de l'Inst. Nat. Polonais d'Écon. rurale à Pulawy*, T. 5, Partie A, pp. 356–378. [In Polish with English summary.]

KŘIŽENECKÝ, J., and J. PODHRADSKÝ. 1927. Über den Einfluss des Hyperthyreoidismus und des Hyperthymismus auf Reifung, Wachstum und Pigmentierung des Gefieders bei ausgewachsenen Hühnern. Zugleich ein weiterer Beitrag zum Studium der Entwichlungsmechanisch-antagonistischen Wirkung der Thymus und der Thyreoidea. *Roux' Arch. f. Entwicklungsmech.*, Bd. 112, pp. 577–593.

KUNDE, MARGARETE M. 1916a. Studies on experimental cretinism. III. Nutritional disturbances, pellagra and xerophthalmia. *Proc. Soc. Exper. Biol. and Med.*, Vol. 23, p. 812.

——. 1916b. Studies on experimental cretinism. IV. The influence of thyroidectomy on the central nervous system. *Proc. Soc. Exper. Biol. and Med.*, Vol. 23, p. 813.

——, and L. WILLIAMS. 1916. Studies on experimental cretinism. II. Nutritional disturbances of bones. *Proc. Soc. Exper. Biol. and Med.*, Vol. 23, p. 812.

KUNKEL, B. W. 1918. The effects of the ductless glands on the development of the flesh flies. *Jour. Exper. Zool.*, Vol. 26, pp. 255–264.

LANDAUER, W. 1929. Thyrogenous dwarfism (myxoedema infantilis) in the domestic fowl. *Amer. Jour. Anat.*, Vol. 43, pp. 1–43.

LARIONOV, W. T. 1930. Der Einfluss der Schilddrüse auf die Regeneration des Gefieders bei *Pyrrhula*. *Roux' Arch. f. Entwicklungsmech.*, Bd. 121, pp. 312–321.

——. 1931. Weitere Versuche über den Einfluss der Schilddrüse auf die Regeneration des Gefieders bei *Pyrrhula*. *Roux' Arch. f. Entwicklungsmech.*, Bd. 124, pp. 54–65.

LIPCHINA, L. P. 1929. [Relation of metamorphosis of axolotls to age, sex, and pigmentation.] *Jour. Biol. et Méd. Expér.*, T. 13, pp. 73–78. [In Russian with German summary.]

LOMBARD, H. C. 1883. Sur les fonctions du corps thyroïde d'après des documents récents. *Rev. Méd. de la Suisse Rom.*, T. 3, pp. 593–604.

MAGNUS-LEVY, A. 1895. Ueber den respiratorischen Gaswechsel unter dem Einfluss der Thyreoidea sowie unter verschiedenen pathologische Zuständen. *Berlin klin. Wchnschr.*, Bd. 32, pp. 650–652.

MARINE, D. 1927. Iodin in the treatment of diseases of the thyroid gland. *Medicine*, Vol. 6, pp. 127–141.

——, and O. P. KIMBALL. 1917. The prevention of simple goitre in man. A survey of the incidence and types of thyroid enlargements in the schoolgirls of Akron (Ohio), from the 5th to the 12th grades, inclusive—The plan of prevention proposed. *Jour. Lab. Clin. Med.*, Vol. 3, pp. 40–48.

MARKOWITZ, C., and W. M. YATER. 1932. Response of explanted cardiac muscle to thyroxine. *Amer. Jour. Physiol.*, Vol. 100, pp. 162–166.

MARTIN, J. H. 1919. Effect of excessive dosages of thyroid on the domestic fowl. *Biol. Bull.*, Vol. 56, pp. 357–370.

MARZA, E., and V. MARZA. 1929. Influence de la thyroïdectomie des parents sur le poids de la thyroïde des descendants. *Compt. rend. Soc. Biol., Paris*, T. 101, pp. 234–236.

MARZA-RUSNAC, E. 1929. Recherches expérimentales sur l'hérédité thyroïdienne. *Rev. franç. d'Endocrin.*, T. 7, p. 320.

MCEACHERN, D. 1935. The metabolism of isolated surviving tissues from animals rendered hyperthyroid with thyroxine. *Bull. Johns Hopkins Hosp.*, Vol. 56, pp. 145–179.

MILLER, D. S. 1935. Effects of thyroxin on plumage of the English sparrow, *Passer domesticus* (Linnaeus). *Jour. Exper. Zool.*, Vol. 71, pp. 293–309.

MIYAGAWA, Y., and K. WADA. 1925. Experimental study on feeding tadpoles of frogs (*Bufo bufo* Japonicus (Schleg.) and *Rana nigromaculata* Hall) with endocrine organ cells. The influence of the constituents of thymus gland cells on the growth of young organisms. (Second report.) *Sci. Rept. Governm. Inst. Inf. Dis., Tokyo Imp. Univ.*, Vol. 4, pp. 299–329.

MORSE, M. 1914. The effective principle in thyroid accelerating involution in frog larvae. *Jour. Biol. Chem.*, Vol. 19, pp. 421–429.

MÜLLER, F. 1893. Beiträge zur Kenntniss der Basedow'schen Krankheit. *Deutsches Arch. f. klin. Med.*, Bd. 51, pp. 335–412.

MURRAY, G. R. 1891. Note on the treatment of myxœdema by hypodermic injections of an extract of the thyroid gland of a sheep. *Brit. Med. Jour.*, Vol. 2 for 1891, pp. 796–797.

NORDENSKIÖLD, ERIK. 1928. The History of Biology. Translated by L. B. Eyre. *New York* (Alfred A. Knopf).

NOWIKOFF, M. 1908. Über die Wirkung des Schilddrüsenextrakts und einiger anderer Organstoffe auf Ciliaten. *Arch. f. Protistenk.*, Bd. 11, pp. 309–325.

OCCHIPINTI, G. 1927. Influenza della tiroide sui caratteri sessuali del piumaggio della quaglia. *Monitore Zool. Ital.*, T. 38, pp. 192–196.

ORD, W. M. 1878. On myxœdema, a term proposed to be applied to an essential condition in the "cretinoid" affection occasionally observed in middle-aged women. *Med. Chir. Trans.*, Vol. 61, pp. 57–78 + 3 pl.

——, and E. WHITE. 1893. Clinical remarks on certain changes observed in the urine of myxœdema after the administration of glycerine extract of thyroid gland. *Brit. Med. Jour.*, Vol. 2 for 1893, p. 217.

PAGET, STEPHEN. 1919. Sir Victor Horsley. A Study of his Life and Work. *London*. Pp. 54–67.

PARKES, A. S., and H. SELYE. 1937. The endocrine system and plumage types. I. Some effects of hyperthyroidism. *Jour. Genetics*, Vol. 34, pp. 297–306 + 2 pl.

PARRY, C. H. 1825. Collections from the Unpublished Medical Writings of the Late Caleb Hillier Parry. Vol. 2. *London*.

PODHRADSKY, J. 1930. Der Einfluss der Hoden bei der Wirkung der Hyperthyreoidisierung auf den Geschlechtscharakter des Gefieders beim Geflügel. *Endokrinologie*, Bd. 7, pp. 241–256.

PUCKETT, W. O. 1937. X-radiation and thyroid-induced metamorphosis in anuran larvae. *Jour. Exper. Zool.*, Vol. 76, pp. 303–323.

RASPOPOVA, N. 1930. [On the action of thyroid gland and of thyroxin on moulting and feather structure in geese.] *Jour. Méd.-Biol.*, T. 2, p. 52.

REBELLO, S. 1914. Action des glandes à sécrétion interne et de leurs extraits sur le développement des plantes. *Compt. rend. Soc. Biol., Paris*, T. 90, pp. 1095–1097.

REVERDIN, J. L., and A. REVERDIN. 1883. Note sur vingt-deux opérations de goitre. *Rev. Méd. de la Suisse Rom.*, T. 3, pp. 309–364.

REZNITCHENKO, M. S. 1926. The influence of the thyroid gland on the development of *Drosophila melanogaster*. *Trans. Lab. Exper. Biol. Zoopark, Moscow*, Vol. 2, pp. 198–200.

——. 1927. Zur Frage über die spezifische Wirkung der Schilddrüse und Ca- und K-Jonen auf die Entwicklung von *Drosophila melanogaster*. *Trans. Lab. Exper. Biol. Zoopark, Moscow*, Vol. 3, pp. 27–35. [In Russian with German summary.]

RIDDLE, M. C., and H. B. TORREY. 1923. The physiological response of *Paramecium* to thyroxin. *Abstract, Anat. Rec.*, Vol. 24, p. 396.

RIDDLE, O. 1928. The establishment of races of pigeons characterized by large or small thyroids. *Abstract, Anat. Rec.*, Vol. 41, p. 112.

ROBERTSON, T. B. 1918. The influence of thyroid alone and of thyroid administered together with nucleic acids upon the growth and longevity of the white mouse. *Austral. Jour. Exper. Biol. and Med. Sci.*, Vol. 5, pp. 69–88.

ROMEIS, B. 1915. Experimentelle Untersuchungen über die Wirkung innersekretorischer Organe. II. Der Einfluss von Thyreoidea- und Thymusfütterung auf das Wachstum, die Entwicklung und die Regeneration von Anurenlarven. *Roux' Arch. f. Entwicklungsmech.*, Bd. 41, pp. 57–119.

——. 1923. Untersuchungen über die Wirkung des Thyroxins. II. Mitteilung. Über die Wirkung des Thyroxins auf Froschlarven. *Biochem. Zeitschr.*, Bd. 141, pp. 121–159.

——, and L. VON DOBKIEWICZ. 1910. Experi-

mentelle Untersuchungen über die Wirkung von Wirbeltierhormonen auf Wirbellose. I. Der Einfluss von Schilddrüsenfütterung auf Entwicklung und Wachstum der Schmeissfliege (*Calliphora vomitoria*). *Roux' Arch. f. Entwicklungsmech.*, Bd. 47, pp. 119–130.

——, and ——. 1932. Die Wirkung von Thyroxin auf den Gasstoffwechsel von Schmetterlingspuppen. III. Teil. Ergänzende mikroskopische Untersuchungen. [Being VII of: Experimentelle Untersuchungen über die Wirkung von Wirbeltierhormonen auf Wirbellose.] *Roux' Arch. f. Entwicklungsmech.*, Bd. 125, pp. 737–769.

——, and J. Wüst. 1932. Die Wirkung von Thyroxin auf den Gasstoffwechsel von Schmetterlingspuppen. II. Teil. [Being VI of: Experimentelle Untersuchungen über die Wirkung von Wirbeltierhormonen auf Wirbellose.] *Roux' Arch. f. Entwicklungsmech.*, Bd. 125, pp. 673–736.

Sainton, P., and J. Peynet. 1926. Dystrophies et dyschronies du système pileux dans le goitre exophthalmique et hyperthyroïdisme expérimental (avec présentation d'animal en expérience). *Bull. et Mém. Soc. Méd. Hôpitaux, Paris*, T. 42, pp. 493–496.

——, and H. Simonnet. 1930. Hyperthyroïde et phanères. Nouvelles études de pathologie expérimentale et comparée. *Ann. de Dermat. et Syphilog.*, T. 1, pp. 1257–1263.

——, and ——. 1931. La transmission héréditaire de la dépigmentation des plumes acquise par l'hyperthyroidisation chez les gallinacés. Analogie avec les troubles observés dans l'hyperthyroïdisme chez l'homme. *Ann. de Dermat. et Syphilog.*, T. 2, pp. 211–213.

Sato, T. 1930. Der Einfluss von synthetisch dargestelltem Thyroxin auf das Wachstum von gezüchtetem Gewebe. *Acta Scholae Med. Univ. Imp. Kioto*, Bd. 13, pp. 39–44.

Schiff, M. 1856. Untersuchungen über die Zuckerbildung in der Leber. *Würzburg.*

——. 1884. Résumé d'une série d'expériences sur les effets de l'ablation des corps thyroïdes. *Rev. Méd. de la Suisse Rom.*, T. 4, pp. 65–75.

Schwarz, E. 1930. Pigmentierung, Form und Wachstum der Federn des Haushuhns in Abhängigkeit von der Thyreoideafunktion. *Roux' Arch. f. Entwicklungsmech.*, Bd. 123, pp. 1–38.

Shumway, W. 1914. Effect of thyroid on division rate of *Paramaecium*. *Jour. Exper. Zool.*, Vol. 17, pp. 297–311.

——. 1917. The effects of a thyroid diet upon *Paramecium*. *Jour. Exper. Zool.*, Vol. 22, pp. 529–563.

Simpson, E. D. 1917. Changes in the growth of skeletal muscle following thyroidectomy in the sheep. *Proc. Soc. Exper. Biol. and Med.*, Vol. 14, p. 289.

Simpson, S. 1924a. The effect of thyroidectomy on growth in the sheep and goat as indicated by body-weight. *Quart. Jour. Exper. Physiol.*, Vol. 14, pp. 161–183.

——. 1924b. Effects of thyroidectomy on the cutaneous system in the sheep and goat. *Quart. Jour. Exper. Physiol.*, Vol. 14, pp. 185–197.

Suarta, J. M. 1930. La influencia de extractos del tiroides y del lobulo posterior de la hipofisis sobre los primeros estados del desarrollo del molusco *Barnea candida* L. *Biol. R. Soc. Espan. Hist. Nat.*, T. 30, pp. 501–506.

Swingle, W. W. 1918. The acceleration of metamorphosis in frog larvae by thyroid feeding, and the effects upon the alimentary tract and sex glands. *Jour. Exper. Zool.*, Vol. 24, pp. 521–543.

——. 1919. Iodine and the thyroid. III. The specific action of iodine in accelerating amphibian metamorphosis. IV. Quantitative experiments on iodine feeding and metamorphosis. *Jour. Gen. Physiol.*, Vol. 1, pp. 593–606; Vol. 2, pp. 161–171.

Terao, A., and N. Wakamori. 1924. Preliminary note on effects of thyroid feeding on the silk worm, *Bombyx mori* L. *Jap. Med. World*, Vol. 4, No. 3.

——, and ——. 1931. Influence of the feeding of the thyroid gland and the anterior lobe of the hypophysis on the second generation of the silk worm, *Bombyx mori* L. *Proc. Imp. Acad. Tokyo*, Vol. 7, pp. 205–207.

Terry, G. S. 1918. Effects of the extirpation of the thyroid gland upon ossification in *Rana pipiens*. *Jour. Exper. Zool.*, Vol. 24, pp. 567–581.

Todd, T. W., R. E. Wharton, and A. W. Todd. 1938. The effect of thyroid deficiency upon bodily growth and skeletal maturation in sheep. *Amer. Jour. Anat.*, Vol. 63, pp. 37–78.

Torrey, H. B. 1923. The effect of dissolved thyroxin on the division rate of *Paramecium*. Abstract, *Anat. Rec.*, Vol. 26, p. 367.

——. 1924. The depressant action of thyroxin on cell division. Abstract, *Anat. Rec.*, Vol. 29, p. 100.

——. 1928. Thyroxin as a depressant of cell division; its effects on the cleavage and early development of sea urchin and ascidian. *Endocrinology*, Vol. 12, pp. 65–80.

——, and B. Horning. 1922. Hen-feathering induced in the male fowl by feeding thyroid. *Proc. Exper. Biol. and Med.*, Vol. 19, pp. 275–279.

——, and ——. 1925. The effect of thyroid feeding on the moulting process and feather structure of the domestic fowl. *Biol. Bull.*, Vol. 49, pp. 275–287.

——, M. C. Riddle, and J. L. Brodie. 1925. Thyroxin as a depressant of the division rate in *Paramecium*. *Jour. Gen. Physiol.*, Vol. 7, pp. 449–460.

West, P. A. 1914. Notes on a sheep thyroid experiment with frog tadpoles. *Science*, n.s., Vol. 39, pp. 918–919.

Wharton, Thomas. 1656. Adenographia. De Glandulis Thyreoidis. Chap. 18. *London*.

Wislicki, L. 1919. Der Einfluss der Schilddrüse auf die Zirkulierende Blutmenge und die Blutdepots des Organismus. *Klin. Wchnschr.*, Bd. 8, pp. 1568–1569.

Woodruff, L. L., and W. W. Swingle. 1923. The effect of thyroid products on *Paramecium*. *Proc. Exper. Biol. and Med.*, Vol. 20, p. 386.

Zavadovski, M. 1925. The effect of single doses of thyroid gland on fowls. *Endocrinology*, Vol. 9, pp. 232–241.

Zavadovsky, B. 1925. The effect of feeding fowls on thyroid gland. *Endocrinology*, Vol. 9, pp. 125–136.

——, and L. Lipchina. 1929. The specific effects of thyroxin on the feathers of birds. *Jour. Biol. et Méd. Expér.*, T. 13, pp. 58–63.

Zavřel, J. 1930. Untersuchungen über den Einfluss einiger Organextrakte auf Wachstum und Entwicklung der Chironomiden. *Roux' Arch. f. Entwicklungsmech.*, Bd. 121, pp. 770–799.

Zawadovsky, B. M. 1926. Eine neue Gruppe der morphogenetischen Funktionen der Schilddrüse. *Roux' Arch. f. Entwicklungsmech.*, Bd. 107, pp. 329–354.

Zawadowsky, B. M., L. P. Liptschina, and E. N. Radsiwon. 1928. Über den Einfluss der Hyperthyreoidisierung auf das Legen der Hühner. *Roux' Arch. f. Entwicklungsmech.*, Bd. 113, pp. 419–431.

——, and M. Rochlin. 1927. Über den Einfluss der experimentellen Hyperthyreoidisierung auf verschiedene Vogelgattungen. *Roux' Arch. f. Entwicklungsmech.*, Bd. 109, pp. 188–209.

——, and A. A. Titajév. 1928. Über den Einfluss organischer und anorganischer Jodpräparate auf die Mauser und Depigmentierung des Hühnergefieders. *Roux' Arch. f. Entwicklungsmech.*, Bd. 113, pp. 582–600.

Zondek, Hermann. 1935. The Diseases of the Endocrine Glands. Third Edition. Translated by Carl Prausnitz. *Baltimore* (William Wood and Co.).

THE WATER BALANCE IN MARINE MAMMALS

By E. S. FETCHER, Jr.

Department of Physiology, University of Chicago

THE problem of the maintenance of the water balance in marine mammals, though it has received some attention, has never been adequately discussed. It is the purpose of this paper to bring together such limited and scattered data as are to be found in the literature with a view to providing the basis for a more complete study of the problem. Kellogg ('38) has recently reviewed the general structural adaptations of whales, and Irving ('39), the problems of respiration in diving animals. Since data are available only for Cetaceans and Pinnipedes, these alone will be discussed, the herbivorous Sirenia not being considered.

In common with other marine forms, the conditions of life of marine mammals are relatively very constant, seasonal variations in temperature and food supply are largely compensated for by migrations.

FOOD AND WATER INTAKE

Most of the food of the Cetaceans consists of animals isotonic with sea-water; baleen whales (Mystacoceti; genera mentioned, *Balaenoptera*, *Balaena*, and *Megaptera*) feed exclusively on the plankton and small crustaceans, as is well known (e.g. Norman and Fraser, '37, and Mackintosh and Wheeler, '29). Much of the food of toothed whales (Odontoceti; genera mentioned; *Delphinapterus*, *Globiocephalus*, *Phocoena*, *Physeter*, and *Tursiops*) is made up of cephalopods, especially squid and cuttlefish, the body fluids of which are also practically isotonic with sea-water. Certainly some Pinnipedes feed largely on crustaceans, Portier ('10), for instance, reports five individuals belonging to two species (*Phoca barbata* and *P. foetida*) the stomachs of which were filled with crustaceans. On the basis of food, it is therefore not possible to differentiate the two types of whale, nor even the seals, for the present purpose.

Several observations indicate that marine mammals do not ordinarily drink sea water (e.g. Mackintosh and Wheeler, '29, Laurie '33). Portier ('10) reports that even the seals referred to above, which have access to fresh water in the form of ice, were not observed to make use of it. Irving *et al.* ('35) report: "None of the seals were observed drinking sea water, but four seals shipped to Toronto in a warm express tank car drank fresh water greedily as soon as a clean supply was available." Suzuki ("Sudzuki" in earlier papers), ('24) observed that whales often drank after they had been wounded. More positive evidence that they do not drink, and that only minimal amounts of sea water are ingested with the food comes from observations of the stomach contents and analyses of the feces. Geiling and Robbins (personal communication), for example, report that the stomachs of numerous white whales (*Delphinapterus leucas*) which they examined, many containing much food, were essentially "dry." Smith ('36) found only traces of Mg and SO_4 in the intestinal residua of the com-

mon harbor seal (*Phoca vitulina*) and correspondingly low amounts in the urine, indicating minimal sea water ingestion. Irving *et al.* ('35) also report low chlorides in the feces. These mammals must therefore depend entirely upon their food as a source of water, unless special mechanisms be assumed.

The water requirements of marine mammals are lower than those of terrestrial mammals as Irving *et al.* ('35) have pointed out. Because of the low and constant temperature of their surroundings, and because of the insulating layer of blubber, no water is needed or used for cooling by evaporation; indeed, they have no sweat glands. Thus the only water outgo is in the urine, the feces, and the exhaled air.

CONSTITUENTS OF BODY FLUIDS

Tables 1 and 2 summarize the relevant data contained in the literature. They include the principal inorganic constituents and the freezing point depressions of various body fluids and of the urine; the total nitrogen for the body fluids, and the urea for the urines. Several other animals and sea water are included for comparison. Most of the data have been reduced to two significant figures, and many have been recalculated to comparable units. Besides the more complete analyses included in the tables, there are the following fragmentary determinations: Two "Seebar" (Ursine seal, *Otoes alascanus* (?)) whole bloods, Suzuki '25a), Δ = 0.70–0.72°C; total N, 39–40 g/l; Cl, 96 milli-Moles/l. Blood sera: 20 samples of finback whale (*Balaenoptera physalus*), Laurie ('33), Cl, 110–120 m-M/l; the following sera freezing point depressions—one dolphin (*Tursiops tursio*), Jolyet ('02), 0.83°C; one porpoise (*Phocoena communis*), Rodier ('99), 0.74°C; Portier ('07), two *Phoca barbata*, 0.64 and 0.66°C, and three *P. foetida*, 0.66, 0.68, and 0.72°C. For the biles of the same seals (no determination for the third *P. foetida*) Portier reports 0.63, 0.66, and 0.71, 0.72°C. For the pericardial fluid of the same dolphin referred to above, Jolyet gives a Δ of 0.80°C, and for the cephalo-rachidien, fluid, 0.81°C. Laurie ('33) lists 22 chloride determinations on blue whale amniotic fluid, distributed from 14 to 120 m-M/l, half between 20 and 51. Measurements of blood specific gravities are scarce for whole bloods, Suzuki ('24) reports 1.06 to 1.08; Myers ('20), 1.04 to 1.06. Suzuki ('24) gives 1.03 for the sera of seven whales. Portier ('07) reports for blue whale aqueous humour Δ = 0.70 and 0.71°C.

Also the following fragmentary determinations on urines: Morimura ('25), seven Sei whales (*Balaenoptera borealis*) had freezing point depressions from 1.8–2.5; average, 2.1°C. Ichimi *et al.* ('25) give 570 m-M/l urea for one finback whale. Portier ('07) reports Δ 's of 0.73 and 4.5°C for two seals. Laurie ('33) determined the chloride concentrations of 45 blue whale (*Balaenoptera sibaldii*) urines; these range from 170 to 450 m-M/l with many at 340–370. Irving's eight chloride determinations on seal urine range from 82 to 260 m-M/l. Two samples of finback whale urine tested by the author gave freezing point depressions of 3.1 and 1.9°C, with corresponding chlorides of 850 and 210 m-M/l. Similar determinations on the urine of a white whale gave 3.2°C and 75 m-M/l respectively. The specific gravities of the urines on which this measurement has been made are typically close to 1.03, with occasional values of 1.04, and one of 1.05. The pH values are about 6.

Good samples of whale blood are difficult to obtain, since the chances of contamination by sea water are many. The greatest difficulty lies in the fact that even

TABLE 1

Body fluids

SAMPLE AND NUMBER OF DETERMINATIONS	SOURCE	Δ°C		MILLI-MOLES/L						
			Total N g/l	Na	K	Ca	Mg	Cl	SO_4	PO_4
Whole blood										
4 finback whales	Okahara ('25)	—	26–28	140–150	56–59	1.4–1.9	1.9–2.7	140	.24	3.6
1 Sei whale	Suzuki ('24)	0.66–0.72	—	130	41	2.7	0.8	100	—	—
1 right whale[a]	Macallum ('26)	—	—	74	49	1.8	2.1	76	—	—
1 humpback whale[b]	Myers ('20)	—	22	—	—	2.7	—	100	—	—
2 sperm whales[c]	Suzuki ('24)	0.66–0.72	—	140	44–49	1.6	1.1–1.2	100	—	—
1 sperm whale	Myers ('20)	—	35	—	—	2.5	—	87	—	—
1 porpoise	Suzuki ('24)	—	—	—	—	4.2	2.3	99	—	—
Serum										
Man	Eichelberger	0.54–0.59	11–14	135–145	3.5–5.0	2.3–2.8	0.5–1.0	99–105	2.3	1.0–1.5
Dog	Hastings ('37)	0.57	9	142	3.7	2.5	—	109	—	—
1 sperm whale	Suzuki ('24)	0.66–0.72	—	170	2.6	0.2	2.3	120	—	—
Teleost-Pollack	Macallum ('26)	1.04	—	180	4.6	3.2	2.5	160	—	—
Limulus	Macallum ('26)	2.04	—	390	13	9.0	41	480	13	—
Pericardial fluid										
? Sei whales	Suzuki ('21)	0.69–0.70	2.9–3.2	160	15–18	2.0	0.5	110–120	5–6	3.3–3.5
Amniotic fluid										
1 m sperm foetus	Suzuki ('25c)	0.58	2.2	28	1.3	8.2	3.8	34	5.6	1.2
4 m Sei foetus	Takata ('21)	0.68	1.7	61	6.4	0.8	0.3	34	14	0.5
Peritoneal fluid										
1 finback whale	Fuse ('25)	0.70	5.4	140	7.7	2.5	2.5	140	2.1	8
Sea water	Dittmar ('84)	2.3	—	490	9.8	10	54	540	27	—

[a] *Balaena mysticetus*. Data were given as g/100g; they have been recalculated assuming a Sp.gr. of 1.06.

[b] *Megaptera nodosa*.

[c] *Physeter macrocephalus*.

TABLE 2
Urine

SAMPLE AND NUMBER OF DETERMINATIONS	SOURCE	Δ°C	MILLI-MOLES/L							
			Urea	Na	K	Ca	Mg	Cl	SO_4	PO_4
Man	Cushny ('26)	1.8	380	150	31	3	4	170	18	25
1 Sei whale	Morimoto ('11)	2.49	400	330	54	5	—	370	38	21
4 Sei whales	Ichimi ('25)	—	420–650	—	—	—	—	260–370	33–43	23–27
4 Sei whales	Schmidt-Nielsen ('21)	2.46(1)	380–530	240–290	36–82	0.3–2	1.6–4.1	180–370	36–45	16–41
5 finback whales	Schmidt-Nielsen ('31)	—	250–420	230–330	56–72	1.8–5.3	2.5–5.8	260–370	—	7.1–41
2 finback whales	Schmidt-Nielsen ('21)	—	380–430	270	67	3.3	6.6	250–390	31–40	7.9–41
1 blue whale	Morimoto ('11)	2.50	420	—	—	—	—	340	(49)	61
1 pilot whale[a]	Suzuki ('25b)	2.01	480	—	—	—	—	180	—	—
2 porpoise (sp. ?)	Suzuki ('25b)	2.28–3.41	480–840	—	—	7.0	10	170–240	—	—
1 white whale	Fetcher	3.23	570	—	—	18	21	39	5.9	34
Seal	Smith ('36)	1.72–3.99	120–1050	—	—	1.3–5.5	0.8–30	200–420	6–97	24–200

[a] *Globicephalus melas.*

under the best conditions hitherto available several hours have elapsed from the time of death of the animal until the time of sampling. This delay permits diffusion of sea water from lungs or intestine into the blood, or from the wound (the animals bleed freely when wounded). Furthermore, because of the heavy insulating layer, the temperature of the whale drops very slowly indeed, so that enzyme and bacterial action may change the samples markedly. It is for this reason that Portier ('07) chose the aqueous humor of the blue whale for his osmotic pressure determinations, since the temperature of this fluid would fall very quickly, and the sclera is certainly completely impermeable to the sea salts. Other body fluids are probably less subject to contamination by sea water than the blood; analyses made on the smaller Cetaceans—the porpoises and dolphins—as well as those of seals shot on ice floes are certainly more reliable; these may be used as a basis for comparison of blood samples of the large whales. It is on this basis that the data are included in the tables and the discussion to follow.

In the opinion of the author Portier's freezing point measurements of seal blood and bile, and of the aqueous humor of the blue whale are reliable; the latter for the reasons given above, and the former because the animals were not in contact with the sea, at the time of death or subsequently. Jolyet's three similar measurements on the dolphin, high as they are, should also be reliable for the samples were taken from a living animal in the air. Suzuki's ('24) analyses of Ursine seal blood are also probably good, since the animals were caught in nets. If these results be taken as approximately correct, the rest of the analyses listed are concordant; and hence these too may be included in the discussion.

The most striking conclusion to be drawn from Table I is that the osmotic pressures are definitely higher than those of terrestrial mammals; a value of 0.69°C may be taken as a first approximation; the variations will be discussed below. Whole blood Na, Ca, and Cl are distinctly higher in marine mammals; on the basis of the one serum analysis available the concentration of NaCl in the cells appears to be nearly the same as in the plasma. The Na and Cl in this one serum analysis appear a little higher than normally found in land mammals, which is supported by Laurie's 20 Cl analyses; it is not prudent, however, to attempt to draw too many conclusions from this one sample. Macallum's whole blood analysis is in sharp contrast to the others with respect to the Na and Cl. He gives no information concerning his method of sampling but the analysis is included because it is evident, especially from the K and Mg concentrations, that it was neither contaminated with sea water, nor diluted with fresh water.

The freezing point depressions of the urines vary from within the human range to well outside, and the same may be said for the inorganic constituents; but the urea is well within normal mammalian range, since the carnivores can secrete up to 2500 m-M/l. The total salt concentrations range from about 16 to about 32 g/l. The sample analyzed by the author is very different from the others, but the low chloride was checked independently of the author's several determinations. It should be noted that most of the samples were collected following unusual activity of the animal.

WATER BALANCE

Both Irving and Smith have concluded from data on common harbor seal urines and estimates of water requirements that

sufficient water, endogenous and metabolic, is provided by their food to permit of a urine secretion similar to that of land mammals. However, they reached this conclusion on the basis of a teleost (herring) diet, on which this seal usually feeds. Smith gives very complete data for the urine of a harbor seal following a meal of macerated clams, which he fed (by stomach tube, for the animal would not eat them) in order to determine the source of the creatinuria he observed. He lists (besides urea, ammonia, creatine, and creatinine) the important inorganic constituents and the rate of urine secretion at approximately hourly intervals for ten hours after the meal. It is possible to integrate these data and calculate the total salt and water output for this period, and to correlate this with the input from the clams, taking into account metabolic water and water requirements. These calculations are summarized in Table 3.

The pertinent data given are PO_4, Cl, SO_4, Ca, and Mg concentrations, and rate of urine formation, at hourly intervals beginning three hours after the meal. The Na and K may be approximated by the difference in milliequivalents of anions (assuming an effective valence of 1.5 for PO_4) and cations reported; and the concentrations of the separate ions estimated on the assumption that the ratio Na/K in grams is 2.5, which is close to a number of the urines of Table 2. The total salt concentration at hourly intervals is thus obtained, whence, by graphical integration, the total salt and total water secreted in 10 hours.

Smith's data from the herring diet are not complete enough to allow of sufficiently accurate corresponding calculations, but he estimates that they check Irving's figures; the latter are used in Table 3, except that Irving's figure of 1 per cent total salt for the herring is replaced with 1.3 per cent, and his results recalculated on that basis. Oyster is used in these calculations instead of clam, no calorific data being readily available for clam; any differences will be negligible for these calculations, which, after all, are only first approximations. No corrections are made for the low fecal salts. The data for herring are based on the whole fish; those for oyster and lobster (included for comparison) on the edible portion. The calorific data, all given in large calories, are from Sherman ('37). The initials indicate the source of data or calculations as being either from Irving (L.I.) or Smith (H.S.).

In this particular case the seal, accustomed to a teleost diet, was unable to take care of the high salt concentration of the mollusk. The conclusion that the kidney must do considerably more work on a diet similar to that of the whale's is obvious. Estimates of the work required of the kidney based on the data of Tables 1 and 2 show the same result; namely, if in the "normal" mammal the increase in concentration of urea from the blood to urine be from 4 to 400 m-M/l, of salts (as NaCl) from 310 to 600 m-M/l, and of osmotic pressure 0.58 to 1.9°C; and in the marine mammal, of urea from 11 to 500 m-M/l, of salts from 370 to 1000 and of osmotic pressure from 0.69 to 2.9°C; then the work done by the "normal" kidney is 1.8 Cal/liter of urine, and that by the marine kidney is 2.5 Cal/liter of urine, or 40 per cent more work. The higher osmotic pressure of the marine mammalian blood saves the kidney some 0.4 Cal/l, or 16 per cent.

From the data presented, and from the above considerations, it is evident that the marine mammals are capable of dealing with salt concentrations outside of the normal range for land mammals. It may be assumed that the high osmotic pressure of the body fluids is connected with this problem of salt elimination. Portier ('10) suggested on the basis of the differences of osmotic pressure he observed in individual seals, and in marine palmipedes (six *Fulamrus glacialis*, Δ's from 0.63 to 0.69, average 0.66°C), that

the osmotic pressure of the blood varied periodically, becoming high at the time of absorption of the meal, falling to a lower value subsequently. It is not possible to evaluate this hypothesis without further (Gilman ('33 *et seq.*) and his co-workers, however, have obtained variations, lasting several hours, of 10–20 per cent in blood osmotic pressures, by injection of hypertonic solutions in various animals.)

TABLE 3

Salt balance estimates

	$\frac{Cal}{l\text{-}O_2}$	$\frac{Cal}{g}$	OYSTER				HERRING (L. I.)				LOBSTER			
			g (per cent)	g/1000 Cal	g. met. water per 1000 Cal*	l-O_2/1000 Cal	g (per cent)	g/1000 Cal	g. met. water per 1000 Cal*	l-O_2/1000 Cal	g (per cent)	g/1000 Cal	g. met. water per 1000 Cal*	l-O_2/1000 Cal
Protein	4.6	4	6.2	124	63	110	11.2	140	71	—	16.4	197	100	170
Fat	4.7	9	1.2	24	25	45	3.9	49	50	—	1.8	22	24	42
Carbohydrate	5.0	4	3.7	74	41	59	—	—	—	—	0.4	5	3	4
Salts	—	—	2.9	58	—	—	1.3	16	—	—	2.9	35	—	—
Water	—	—	85	1700	—	—	80	1000	—	—	77	920	—	—
Totals (Rounded)				2000	130	210		1300	120	240		1200	130	210

* For protein: g × 0.51 (corr. for urea) Newburgh ('30).
For fat: [(l-O_2) (1 − R.Q.) (2 × 18/22.4)] [1 + 0.12].
For carbohydrate: g. starch × 0.56.

1000 CAL	OYSTER	HERRING	LOBSTER
Total water available	1800 g	1100 g	1100 g
Water to saturate air required for metabolism from 15 to 35°C (6 per cent inhaled air removed (L.I.))	100 g	110 g	100 g
Water for feces (L.I.)	200 g	200 g	200 g
Water available for urine	1500 g	800 g	800 g
Calc. average urinary salt conc. (g. salt/1000 cal. + water for urine)	39 g/l	20 g/l	44 g/l
Salt secreted in 10 hours (H.S.)	33 g	—	—
Water secreted in 10 hours (H.S.)	1100 g	—	—
Average urinary salt conc. 10 hours (H.S.)	30 g/l	—	—
Salt residue [58 − (1500 × 30)/1000]	13 g	—	—
Calc. dehydration of 30 kg animal from salt residue (13/.03 × 22,500)	1.9%	—	—
Calc. body fluid osmotic pressure increase, 30 kg animal $\left(\frac{13}{58.5 \times 22.5} \times 1.86\right)$	0.02°C	—	—

experimental work, except to observe that the freezing point depressions listed in Table I show considerable variation, and that in the light of other mammalian experience such variations are improbable. This hypothesis contributes little to the problem at hand, for it refers primarily to to the rate of renal secretion relative to the rate of intestinal absorption, and only secondarily to the increased urine con-

centration possible with higher blood osmotic pressure.

It will be seen that there is a discrepancy between the range of normal variation of the total urinary salt concentration in the analyses tabulated (16 to 32 g/l, with many at 29 g/l) and the estimate of average total urinary salt concentration following a meal of invertebrates (39 or 44 g/l). One would expect that many of the urines would approximate this figure if the kidney alone were responsible for removal of all ingested salt, and if no water were available other than that from the food. Actually few approach, and only two complete analyses (Smith, for the clam diet, 36 and 37 g/l) even reach it, whereas a great many are well below. It would seem impossible on the above assumptions for baleen whales, at least, to afford the comparatively dilute urines reported; except after excessive renal work, for which no evidence is to be found. It is hardly probable that the discrepancy is coincidental, since so many complete and partial analyses are available, nor does it seem possible that the salt and water estimates of the food could be so greatly in error. If these premises be accepted, it then becomes necessary to assume some special mechanism for the elimination of salts, or for provision of relatively salt free water, or both, the nature of which must be a matter of speculation at present. One is tempted to suspect modification of the buccal glands, since cutaneous glands are absent. The Cetaceans apparently have no salivary glands (Schulte, p. 432; Sonntag, '22; Robbins, personal communication) but do have glands in the tongue "more numerous than any other *Mammalia*" (Sonntag, '22). No histological account of these has been found. Perhaps the fact that Cetaceans can survive only a few hours out of water is related to this problem, as well as to that of heat regulation.

CONCLUSION

In conclusion, it now appears reasonably certain that those marine mammals for which data are available have undergone not only morphological adaptations, but adaptations of their cellular physiology, and possibly modifications of their special physiology to compensate for the medium in which they live. The higher, possibly fluctuating, osmotic pressure of the body fluids, and the greater capacity of the kidney, are apparently merely extensions of normal mammalian functions. Only further experimental work can decide to what extent this is true for any special mechanism for salt elimination or water intake.

SUMMARY

The literature relating to water balance is reviewed. The available data indicate a blood freezing point depression of about 0.69°C. Whole blood Na, Ca, and Cl are somewhat higher than in land mammals. Most urine total salt concentrations are in the range of 16 to 32 g/l with many at 29 g/l; urea concentrations are "normal." Estimates of urine salt concentrations are made from the composition of vertebrate and invertebrate foods, assuming no water intake other than that in the food. It is concluded that those marine mammals which subsist largely on vertebrates have no special salt clearance problem; whereas those living on invertebrates probably do have a special mechanism for the reduction of urinary salt concentration.

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LIST OF LITERATURE

CUSHNY, A. R. 1926. The Secretion of Urine. Longmans, Green & Co., *London.*

DITTMAR, W. 1884. Report on the composition of ocean water. Challenger Report, Physics and Chemistry, Vol. I, Part 1.

EICHELBERGER, L. Unpublished analyses of human serum.

FUSE, N. 1925. Untersuchen über Cetacea XVII. Über die Peritonealflüssigkeit. *Jap. J. Med. Sci.* II, *Biochem.*, 1, 51–53.

GILMAN, A., and G. R. COWGILL. 1933. Osmotic relations between blood and body fluids. *Am. J. Physiol.*, 103, 143–152; 104, 235–241, 476–479.

GILMAN, A. 1937. Voluntary water intake and blood osmotic pressure. *Ibid.*, 120, 323–328.

HASTINGS, A. B., and L. EICHELBERGER. 1937. The exchange of salt and water between muscle and blood. *J. Biol. Chem.*, 117, 73–93.

ICHIMI, T., *et al.* 1925. Untersuchen über Cetacea XXIV. Über die Zusammensetzung des Harns. *Jap. J. Med. Sci., Biochem.*, 1, 119–124.

IRVING, L., K. C. FISHER, and F. C. MCINTOSH. 1935. The water balance of a marine mammal, the seal. *J. Cell. Comp. Physiol.*, 6, 387–391.

IRVING, L. 1939. The respiration of diving mammals. *Physiol. Rev.*, 19, 112–134.

JOLYET, M. F. 1902. Sur quelques conditions de l'adaptation des mammifères cetacés à la vie constante aquatique. *Comptes rend. Soc. de Biol.*, 54, 293–295.

——. 1906. *Ibid.*, 58–1, 553–554.

KELLOGG, R. 1938. Adaptation of structure to function in whales. "Cooperation in Research." *Carnegie Inst. of Washington Publication* No. 501, pp. 649–682.

LAURIE, A. H. 1933. Some aspects of respiration in blue and fin whales. Discovery Reports. Cambridge Univ., *Cambridge*, 7, 363.

MACALLUM, A. B. 1926. Paleochemistry of body fluids and tissues. *Physiol. Rev.*, 6, 316–356.

MACKINTOSH, N. A., and J. F. G. WHEELER. 1929. Southern blue and fin whales. Discovery Reports. Cambridge Univ., *Cambridge*, 1, 257.

MORIMOTO, Y., M. TAKATA and M. SUDZUKI. 1921. Untersuchen über Cetacea I. Vorversuche. *Tohuku J. Exp. Med.*, 2, 258.

MORIMURA, S. 1925. Über die physikalish-chemischen Eigenschaften des Seiwalharns. *Jap. J. Med. Sci.*, II *Biochem.*, 1, 25–27.

MYERS, R. G. 1920. A chemical study of whale blood. *J. Biol. Chem.*, 41, 137–143.

NEWBURGH, L. H. and M. W. JOHNSTON. 1930. The Exchange of Energy between Man and His Environment. Charles C. Thomas. *Springfield.*

NORMAN, J. R. and F. C. FRASER. 1937. Giant Fishes, Whales, and Dolphins. Putnam and Co., *London.*

OKAHARA, Y. 1925. Untersuchen über Cetacea XV. Über die Zusammensetzung des Finwalblutes. *Jap. J. Med. Sci.* II *Biochem.*, 1, 43–50.

PORTIER, P. 1907. Determination de la pression osmotique du sang et des liquides internes des vertebrés des contrées polaires arctiques. *Soc. de Biol.*, 62, 627–630.

——. 1910. Pression osmotique des liquides des oiseaux et mammifères marins. *J. Physiol. Path. Gener.*, 12, 202–208.

RODIER, E. 1899. Le sang et les liquides internes des animaux marins. *Trav. Soc. Sci. et Station Zool. d'Arcachon*, p. 103.

SCHMIDT-NIELSEN, S. and J. HOLMSEN. 1921. Composition de l'urine des baleines. *Arch. Intern. de Physiol.*, 18, 128–132.

——, and A. JOHNSEN. 1931. Sur la composition de l'urine des baleines II. *Kgl. Norsk. Vidensk. Selsk. Forhandl.*, 4, 121–123.

SCHULTE, H. VON W. 1914. Anatomy of a Foetus of *Balaenoptera borealis.* "The Sei Whale." Memoirs of the American Museum of Natural History, New Series, Vol. I, Part VI, p. 432.

SHERMAN, H. C. 1937. Chemistry of Food and Nutrition. The Macmillan Co., *New York.*

SMITH, H. W. 1936. The composition of the urine of the seal. *J. Cell. Comp. Physiol.*, 7, 465–474.

SONNTAG, C. F. 1922. The comparative anatomy of the tongues of the mammalia VII. Cetacea, Sirenia, and Ungulata. *Proc. Zool. Soc. Lond.*, pp. 639–657.

SUDZUKI, M. 1921. Untersuchen über Cetacea III. Über die Pericardialflüssigkeit des Seiwals. *Tohuku J. Exp. Med.*, 2, 355.

——. 1924. *Idem* VIII. Über das Blut. *Ibid.*, 5, 419.

SUZUKI [SUDZUKI], M. 1925. (a) Über das blut des Seebärs. *Jap. J. Med. Sci.*, II *Biochem.*, 1, 71–72.

——. 1925. (b) Untersuchen über Cetacea XX. Über die Zusammensetzung des Harns von Delphinidae. *Ibid.*, 69–70.

——. 1925. (c) *Idem* XXIII. Über das Fruchtwasser des Pottwals. *Ibid.*, 97–101.

TAKATA, M. 1921. *Idem* VII. Über das Fruchtwasser des Seiwals. *Tohuku J. Exp. Med.*, 2, 459.

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *1901 East Madison Street, Baltimore, Maryland U. S. A.*

CHEMISTRY AND SEX

Being a review of the second edition of *Sex and Internal Secretions*. Edited by Edgar Allen, C. H. Danforth, and E. A. Doisy. *Baltimore* (Williams & Wilkins Co.), 1939. Pp. xxxvi + 1346. $12.00.

By Gregory Pincus, The Biological Laboratories, Clark University, Worcester, Massachusetts.

The publication in 1922 of the last edition of F. H. A. Marshall's classical *Physiology of Reproduction* marked the end of an era of investigation that may well be termed the pre-chemical. We are now in the boiling midst of the chemical era, initiated decisively in 1923 with Allen and Doisy's demonstration of a water-insoluble oestrogenic ovarian follicular hormone, given impetus by the discovery of a ready source of such substance in large amount in pregnancy urine, further accelerated in 1927 by McGee's preparation of a lipoid androgen fraction of testis tissue and the finding of similar material in male urine, and carried into complex new fields by the simultaneous publication in 1927 of studies by Smith and Engel and by Aschheim and Zondek of anterior pituitary gonadotropic principles. As a result of these initial accelerations organic chemists have produced, with increasing velocity, chemically pure steroids and related compounds that are (or mimic the activities of) the effective hormones of the gonads. In addition to the gonadotropic there have been prepared pituitary products that are adrenotropic, thyreotropic, mammotropic, lactogenic, diabetogenic, ketogenic, and so on. The physiologists and experimental morphologists have employed the chemical preparations for the investigation not only of specific hormonal effects but also for new approaches to, among a host of others, such varied problems as the nature of sex-determination in vertebrates, of parturition in mammals, of genital pathology in man.

In this second edition of *Sex and Internal Secretions* nine zoölogists, seven anatomists, seven biochemists, a geneticist, a cytologist, a psychologist, and a gynecologist attempt in some 1300 pages to present the genetic and endocrine basis of our knowledge of sex function. Even with this formidable authorship an exhaustive exposition is disclaimed. The book is divided into five sections concerned with: (A) the biological basis of sex; (B) the physiology of the sex glands, germ cells, and accessory organs; (C) the biochemistry and bioassay of gonadal hormones; (D) the hypophysis and the gonadotropic hormones of blood and urine in relation to the reproductive system; (E) the additional factors in sex functions and endocrine applications in man.

The presentation of the subject matter is of course bound to differ from chapter to chapter with so varied an authorship, but the general accomplishment of the book may be appraised by stating at once that an intensive reading will yield an extraordinary return. The biology of sex and its manifestation, particularly in the

vertebrates, is thoroughly and soundly presented. The editors have done a first-rate job of assembling and coördinating the various chapters into an orderly whole. It is obvious that their task was an extremely difficult one. Even casual perusal reveals that certain chapters were completed late in 1938 whereas others were completed in 1937. This has necessitated addenda to a number of chapters.

The book opens with a short introductory chapter by Dr. Frank Lillie concerned chiefly with establishing the differences between sex determination and sex differentiation. Dr. Lillie insists that "the sex of the gametes and sex in bodily structure or expression are two radically different things." Control of sex determination is "chromosomal." Sex differentiation is either nuclear (as in insects) or "taken over by intracellular agents" such as hormones in the vertebrates. Exception might be taken to the notion of absolute chromosomal control of sex differentiation in insects on the basis of the demonstration of Ephrussi, Beadle *et al.* that extracellular agents are responsible for eye differentiation in *Drosophila*. Presumably in development the gonads and accessory structures may also be influenced by similar substances. Until we are more completely informed of the physiological mechanisms involved in early embryology absolute distinctions can serve only as convenient guides. For this reason Castle's idea of sexuality as plus and minus variations in a single scale of graduations may have validity in spite of Lillie's rejection of it for his dichotomous scheme.

The cytological and genetic basis of sex is presented posthumously by Dr. Bridges. In this chapter the author's ideas of the rôle of genetic balance in sex determination are clearly elaborated and recent work in insects particularly is brought into line with his theories. As a result there is a somewhat cavalier treatment of Goldschmidt's work. A rather single-minded absorption with his own hypotheses led Bridges to present certain objections, particularly to Goldschmidt's "time law of intersexuality," at the same time ignoring Goldschmidt's factual and theoretical refutations of these criticisms.

The two succeeding chapters by Dr. Willier and Dr. Witschi are, in the opinion of this reviewer, superlative presentations of the facts of the embryonic development, of sex and its experimental modification. Witschi's general theory that "masculinization and feminization depend directly or indirectly on the relative activity of gonadal medulla or cortex and their related tissues" is supported by a beautiful array of evidence.

Dr. Domm in Chapter V discusses modifications in sex and secondary characteristics in birds. In accounting for certain primary modifications the author declares that the gonadal cortex produces oestrogens; the medulla, androgens. This is treading on dangerous ground since either gonad *may* produce both. Males and females excrete both, and castrates have been shown to excrete both. (Marker has recently isolated androsterone, dehydro-androsterone and oestrone from steer's urine, Englehart and Callow and Parkes demonstrated oestrogen in cortical extracts.) It also is to be regretted that, in an otherwise rather complete exposition of the factors governing gonad development in birds, Benoit's extraordinary demonstration of the effect of light upon the duck pituitary is omitted. Domm's account of the control of plumage dimorphism is an extremely competent presentation of the modern view of this classical problem.

A summarizing chapter by Dr. Danforth concludes the first section of the book. It is concerned broadly with the origin and evolution of sex, and illustrates with apt examples the balance between genic and endocrine factors. This thoughtful disquisition on the development of the gene-hormone dichotomy tempts the reviewer to elaborate upon the putative reality of extracellular and intracellular hormones. Resisting temptation, one may, nonetheless, wonder about the statement that "In general it seems more illuminating to think of the cells as utilizing the hormones rather than of the hormones as actively stimulating the cells." The statement itself may be a tautology.

The second section begins with Dr. Moore's chapter on the biology of the

testis. It presents a very clear exposition of the spermatogenetic and endocrine functions of the testis and the physiological control of both. The author is at a loss to explain the widely conflicting papers on the effects of castration on learning ability in rats. One possible explanation may be that congenital (genetic) differences between strains are involved. The matter is of some consequence in view of recent indications that mental disease and androgen metabolism may be related. An excellent critique of various pseudo-scientific theories of rejuvenation distinguishes this chapter.

Drs. E. Allen, Hisaw and Gardner follow with a long, informative, laconic chapter on ovarian function. Over half of the chapter is devoted to a discussion of periodicity in the female. In evolving a theoretical explanation of the control of the oestrus cycle, the authors give scant consideration to two extremely relevant experimental findings. The first is the demonstration (by Robson and Westman and Jacobsohn) that, in the absence of the pituitary, oestrogen alone maintains functional corpora lutea; the second is the possibility of an endogenous uterine periodicity as indicated by Zuckerman and Hauptstein and Bühler. There is, indeed, a sentence to the effect that the latter authors "report experimental evidence" on the rôle of the uterus in regulating the oestrus cycle, but the actual evidence is not cited. Again, in offering a probable explanation of menstruation, the authors give no consideration to the evidence of Smith and Smith that a "positive precipitating factor" may be involved. Finally, in considering the evidence from studies on oestrogen excretion, the authors nowhere mention that excretion studies which do not involve the freeing of "bound" oestrogen are of negligible significance and that furthermore a large number of such studies are thereby vitiated. The rôle of known detoxicating mechanisms is not recognized in a description of the rapid disappearance of injected oestrogen. Excellent descriptions of the qualitative effects of the ovarian hormones on various end-organs occupy a large section of this chapter. The discussion of atypical growths following oestrogen administration is especially good. A concluding section is devoted to evolutionary trends in ovarian function.

The chapter on ovulation, fertilization and the transport of eggs and sperm by Dr. Hartman is written with gusto and sparkle. It reads well and tells all worth knowing.

Dr. Newton's brief chapter on endocrine function in pregnancy is notable for its detached critical outlook. Its brevity is largely due to a paucity of informative physiological data on this most important phase of the reproductive cycle.

This second section of the book concludes with a discussion of the mammary glands by Dr. Turner. A brief statement of fact about the nature of mammary development in ontogeny and during reproductive function is followed by a full presentation of fact about the endocrine control of this development. The latter is marred by the citation of conflicting evidence on the rôle of the hormones. Little or no attempt is made to evaluate often contradictory findings. This may be due in part to the lack of comparable quantitative measurements in the original papers.

The third section of the book contains chapters on the biochemistry of the androgens, oestrogens, and progestin, by Drs. Koch, Doisy, and W. Allen, respectively. All three are succinct, capable presentations. Dr. Doisy's chapter, completed in 1937, presents more recent information rather sketchily in an addendum and in footnotes. Thus the text cites the conversion of ergosterol to oestrone by Marker *et al.* and recent authoritative criticism of this putative conversion is too briefly given in a footnote. Again, the lengthy series of papers by Marker and his colleagues on oestrogen excretion and their discussion of the biochemical origin of the hormones is not mentioned.

Dr. Gustavson's chapter on the assay of androgens and oestrogens is rather summary and overweighted by the author's personal experience. Various valuable assay methods are not presented, such as Astwood's excellent short method (mentioned by Allen, Hisaw, and Gardner earlier in the book) and other techniques involving the use of the uterine weight

in immature rats and mice. The colorimetric determination of urinary androgen as developed by Oesting, Callow and others is completely ignored. Even in citing the conventional Allen-Doisy test for oestrogen the author gives no express statement of its limits of accuracy. In fact, the statistical considerations which must validate any assay procedure are referred to only by a reference to the general work of Trevan and a somewhat outmoded paper by Coward and Burn. The reader is referred to a recent excellent paper by Emmens (published by the Medical Research Council of Great Britain) which might well serve as a model. The reviewer is rather insistent about this matter because he believes that future research on the physiological chemistry of androgens and oestrogens must involve accurate methods for their quantitation.

The section on hypophyseal hormones concerned with reproductive processes begins with Dr. Smith's careful, extremely readable account of the effects of pituitary ablation and its implantation. Dr. Fevold discourses eloquently on the follicle stimulating and luteinizing gonadotropic hormones. One is left with the impression that the dual hormone hypothesis, or any other hypothesis of the pituitary substances concerned in gonad stimulation, requires the final chemical evidence of pure substances for full substantiation. Dr. Engle's account of the gonadotropic substances of blood, urine and other body fluids is unexceptional. A clear differentiation is made between the various "pituitary-like" substances and order is made of a very disordered literature on their various physiological effects. Dr. Severinghaus' capable chapter on pituitary cytology attempts to relate the microscopic picture of cell changes in the anterior pituitary to functional effects of pituitary secretion. The correlations are fairly good, e.g. basophilic degranulation with clear evidence of gonadotropic secretion, but certain obvious lacunae should encourage the aspiring pituitary histophysiologist to further endeavour. In this connection there is unfortunate omission of any mention of the work of Dawson and his collaborators on the anterior pituitary "carmine cell."

Drs. Riddle and Bates conclude this section with an authoritative account of lactogenic anterior pituitary hormone.

The final section begins with Dr. Nelson's laudably critical examination of the putative rôle of the thymus and pineal glands in reproductive processes. He concludes that neither gland has much valid claim to being an endocrine organ. Dr. Mason's account of the rôle of the vitamins in sexual processes serves to indicate the paucity of our knowledge in this field. Of all the vitamins, E alone can now be held responsible for a rather specific rôle. Dr. Stone's chapter on "Sex Drive" brings the previous edition's account up to date with relatively little new information. It is surprising that this field has not been more fully exploited. The concluding chapter by Dr. Pratt on "Sex Functions in Man" brings one up with a shock, because it indicates that despite the previously detailed enormous advances in the sexual physiology of animals similar knowledge of man is either lacking or deficient. Dr. Pratt rightly points out that we are handicapped not merely by the unsuitability of man for certain experimental purposes, but even in those situations where valuable data might be forthcoming objective criteria are lacking. Thus the usefulness of various hormone preparations as medicines can scarcely be judged by data based on such imponderables as "improvement," "no relief," et cetera. It is unfortunate that the author himself presents a table instancing the equally "good" effect in relieving menopausal symptoms of the oestrogens, plain oil, phenobarbital, and other materials in which the effects are measured by exactly these scorned subjective criteria. The reviewer hopes that in future editions Dr. Pratt will be more liberal in his citations, e.g. in discussing the sex hormones and homo-sexuality he says "assays of urine for male and female hormone have shown . . . a disturbance of the normal balance," but no papers are cited.

"Sex and Internal Secretions" should be taken not merely as a handbook for the student and a lexicon for the scholar. It offers, as well, a basis for future investigation. In almost every chapter the as-yet-

unexplored is specifically indicated. If one were to dare to generalize, the major problem that invites exploitation is the mechanism of the action of the hormones whose qualitative effects are so well detailed. What might be called the "intimate biochemistry" of the reproductive processes is scarcely known. What the hormones do is told well, but how they do it is still a large and open question. If this book were nothing else it would be invaluable as an incitement to the curious mind. But it is far from nothing else. It is, in fact, a remarkable contribution to knowledge in a vast, engaging realm of biology.

BRIEF NOTICES

EVOLUTION

THOUGHTS ON EVOLUTION. *I. Phases of Evolution. Anthropological Series of the Boston College Graduate School, Vol. IV, No. 1. By Joseph J. Williams, S.J. Boston College Press, Chestnut Hill, Mass.* $1.00. 9¾ x 6¼; 56; 1939 (paper).

This monograph presents, in a scholarly fashion, the different phases through which the theories on the origin of life and the process of organic evolution have passed since their inclusion into the realm of human thought. The present trend is held to be away from the practice of considering Darwinism and evolution as synonymous, and away from the hope of ever obtaining the environmental conditions necessary for the spontaneous generation, or the re-creation, of life. Darwin's theory of the origin of the species by means of natural selection is said to be only a small portion of the whole theory of evolution, inasmuch as it does not account for the origin of life or the divergence of forms down to the species. His theory of natural selection, or survival of the fittest, is attacked on the grounds that no scientific evidence is yet available which indicates that the fittest do survive, or conversely, that those which survive are the fittest. The thesis is closed with praise for Darwin's theory for the stimulus it furnished for further investigation in evolution, but with severe criticism for the dogmatic persistence of some scientists in clinging to popular authority without the necessary scientific evidence to support such a stand.

The volume is concluded by a long list of bibliographic references.

LEXICON OF GEOLOGIC NAMES OF THE UNITED STATES (INCLUDING ALASKA). *(Also includes the names and ages, but not the definitions, of the named geologic units of Canada, Mexico, the West Indies, Central America, and Hawaii). Part 1, A-L; Part 2, M-Z. U. S. Department of the Interior. Geological Survey. Bulletin 896. Compiled by M. Grace Wilmarth. Government Printing Office, Washington, D. C.* $2.50 for the two volumes. 9⅛ x 5¾; 2395; 1938 (paper).

This lexicon, compiled as a "time saver for the busy geologist" will be a valuable addition to any biological library and particularly to those where ecology and paleontology are special subjects. The definitions state, briefly, the lithology, thickness, age, underlying and overlying formations, and type locality.

In order to avoid undesirable duplication of names, and to supply information frequently sought, the names, geographic areas, and ages of the principal underground geologic units have been listed; also the names and geographic regions of Pleistocene moraines, with a reference to the publication in which an outline or a description of each will be found. The names of coal beds and ore beds have not been listed. The time terms have also been listed, but the full definitions of the era, system, and series terms having been given in United States Geological Survey Bulletin 769, 1925, only very brief definitions of them are given here, with a reference to Bulletin 769.

Stratigraphic charts "against which the definitions, redefinitions and geographic distribution of the units could be checked" have been prepared. They do not accompany the lexicon but we gather that they may be obtained from the U. S. Geological Survey.

GENETICS

ORIENTAMENTI DELLA MODERNA BIOLOGIA. *Micromerismo od Organicismo? Mutazionismo o Lamarckismo?*

By Mario F. Canella. Nicola Zanichelli Editore, Bologna. 15 Lire. 9¾ x 7; 141; 1939 (paper).

In accordance with some of the philosophical views held by Bertalanffy, and accepting Raffaele's criticism of the gene theory, the author takes issue with the mutation theory of organic evolution. His arguments cover all the essential postulates of modern genetic theory. To begin with he is far from convinced about the characteristics and functions generally attributed to the genes and justifies his opinion by pointing out inconsistencies in the dicta of the geneticists themselves. But the author is mainly concerned with the mutation theory and he emphasizes that it implies, among other things, that chance mutations have brought about the transformation of Selachii into amphibia, amphibia into birds and mammals, anthropoids into Hominidae. In his opinion it is inconceivable, and there is no evidence whatsoever to show, that such a series of evolutionary changes could be the product of chance mutations. Consequently, he notes, mutation could possibly explain only the formation of varieties within the species. If this is so, he continues, it means that we must assume either that species are fixed and accept the existence of a Deity who has ordered the universe or else seek another explanation of evolution. The author believes that one has not far to seek since Lamarck furnishes the needed theoretical approach to the study of organic evolution. As an embryologist he finds in Lamarckism the theory that seems closer in agreement with the facts he has observed, and therefore he pleads for a better understanding of these principles, strongly chiding those who have gone out of their way to heap ridicule on Lamarck. In turn he becomes very sarcastic about the validity of the many experiments made to disprove the inheritance of acquired characters, pointing out that as planned they disregard the most important aspects of Lamarck's views. The author demonstrates a profound knowledge of the literature and a philosophical ability of no mean value. Although not quite convincing he deserves attention as do all who criticize established dogmas.

YOU AND HEREDITY.

By Amram Scheinfeld, assisted in the genetic sections by Morton D. Schweitzer. Frederick A. Stokes Co., New York. $3.75. 8¼ x 5¾; xvii + 434 + 10 plates; 1938.

It might seem that nothing could be a farther cry from an exact science than fortune telling. Yet *You and Heredity* looks into the past, examines the present, and foretells the future. It is a genetics book written for the layman by a layman (who has read and consulted eminent authorities). In simple terms the mechanisms of heredity are revealed, and the significance of these findings in human lives is pointed out, at the same time shattering many age-old superstitions. Forecast tables are issued which enable one to predict future appearances and defects in himself and children on the basis of characteristics noted among ancestors or present relations.

Interesting sections tell of the inheritance of disease, mental traits, talents, and length of life. The closing chapters contain negative and positive eugenic measures which can be applied by society as a whole and by the individual for the betterment of his own life and the lives of his offspring.

By and large the author is careful to state only the facts of heredity and to label any doubtful points. However, he makes a few hidebound statements which have at one time or another exhibited leaks. Chief among these is the allegation that there can be absolutely no inheritance of acquired characters, whereas certain studies suggest the wisdom of less dogmatism on this point. All in all the volume is well written, containing a good index and a selection of useful references.

L'HYGIÈNE DE LA RACE. *Étude de Biologie Héréditaire et de Normalisation de la Race. By G. Banu. Masson et Cie, Paris;*

M.O., Imprimeria Natională, Bucharest. 80 francs. 9½ x 6¾; vii + 403 + 1 folding chart; 1939 (paper).

By the term "race hygiene" the author means the health and welfare of a national or ethnic group. In this volume he outlines the method of study that in his opinion is most apt to insure further progress in national well-being. As he states it, the main objective of research in race hygiene should be the investigation of all the controllable factors that can modify favorably or unfavorably the mental and physical qualities of future generations. From this statement it is obvious that the author stresses particularly the genetic aspect of human biology and in fact the greater part of the book is taken up by a discussion of the inheritance of physical and mental traits and the hereditary transmission of disease susceptibility. He notes that much more information is needed in genetics, but nevertheless he is a very strong advocate of the more extreme proposals made off and on by certain eugenists. Numerous aspects of human biology are covered in this book since the author examines the demographic conditions of several countries relative to social hygiene and, in particular, to eugenic measures. The reader will find mentioned here a fair, even though limited, account of the work of European investigators in this field but very little regarding the contributions of American students of the subject.

ANGEWANDTE TIERZUCHT *auf rassenbiologischer Grundlage.*

By Carl Holecek-Holleschowitz. Verlag von Julius Springer, Vienna. RM. 12. (paper); RM. 13.50 (cloth). 10 x 7; xiv + 176; 1939.

This excellent treatise is concerned with the origin, development, and present-day methods in the breeding of domesticated animals in Europe. Dr. Holecek-Holleschowitz presents a description of the early European horse, cow, pig, sheep and goat, together with a summary of the effects of domestication and scientific breeding on the present day forms of these animals. With the advent of genetics as a separate science has come a great advance in the development of specialized types of domestic stock. Pure strains of race- and dray-horses; of beef and milk cows; of wool-and meat-producing sheep; as well as wool-, meat-, and milk-producing goats have been developed as a result of the trend based on the principle of race biology. With the newer knowledge of animal genetics and animal nutrition, have come attempts to hybridize certain types of domestic animals so as to combine into one animal the valuable qualities of several pure strains, and it is of interest to note that these attempts have not been entirely without success.

The volume is illustrated by more than 100 photographs, and contains a 5-page table of contents.

LIFE PROCESSES IN GRAY NORWAY RATS DURING FOURTEEN YEARS IN CAPTIVITY. *The American Anatomical Memoirs No. 17.*

By Helen Dean King. Wistar Institute of Anatomy and Biology, Philadelphia. $2.00. 10 x 6⅞; 72 + 2 plates; 1939 (paper).

Data for the eleventh to twenty-fifth generations are given in this second report on the studies of the changes in various life processes that take place in the *Rattus norvegicus* when bred in captivity for a number of generations (since 1919). Growth and variability in body weight, the reproductive period, the sex ratio, mortality, and mutations are some of the processes discussed in the text. The report on the first ten generations was published in 1929.

Plates of the hooded and curly mutants are given in the 1939 report. The hooded stock was developed by selective breeding; the curly mutation (a dominant mutation heretofore unknown in rats) was attributed to gene changes occurring in rats long bred in captivity. Other mutants are discussed in the text.

The late Dr. Donaldson's researches on organ changes in the fifteen generations (11–25) will be published later.

THE GENETICS OF GARDEN PLANTS. *Second Edition.*

By M. B. Crane and W. J. C. Lawrence. With a Foreword by Sir Daniel Hall. The Macmillan Co., New York and London. $3.25. 8½ x 5½; xxi + 287; 1938.

The first edition of this book (cf. Q.R.B., Vol. 10, p. 342) appeared in 1934. Since that time progress in genetics has been so great that many additions and occasional rewritings have been required to bring the subject matter up to date. The additions mainly consist of a discussion of linkage in *Zea mays;* multiple genes; genetics and cytology of *Iris* species; a chapter describing the chemical and genetical basis of flower color; a discussion of the genetics of melons; recent results of genetics of incompatibility in diploid and polyploid plants, etc.

RECENT ADVANCES IN PLANT GENETICS. *F. W. Sansome and J. Philp. Second Edition Revised and Rewritten.*

By F. W. Sansome. With Foreword by Sir A. Daniel Hall. P. Blakiston's, Son and Co., Philadelphia. $5.50. 7¾ x 5¼; xii + 412 + 8 plates; 1939.

In this second revision Chapters II, III and X have been extensively rewritten and others have been altered "in order to express the newer viewpoints of geneticists." A chapter on variegation and on chimaeras is included and there is a discussion of the more biological aspects of genetics, "since a common misconception that genetics is a conglomeration of cytological theories, statistical work and peculiar terminology is all too prevalent."

GENERAL BIOLOGY

CONSERVATION IN THE UNITED STATES.

By A. F. Gustafson, H. Ries, C. H. Guise and W. J. Hamilton, Jr. Comstock Publishing Co., Cornell Heights, Ithaca, N. Y. $3.00. 9½ x 6½; xi + 445; 1939.

"It is the aim of this book to present the basic principles of conservation to the reader so that he may gain an understanding of tomorrow's problems and be in a position to deal effectively with them."

All forms of conservation are considered: soil and water, forest, fish, game, and mineral resources. The authors do not take an alarmist attitude, but rather give a critical evaluation of the state of depletion as it now exists, the problems that confront us, and methods by which we can deal with these problems. Educated individuals, through public coöperation and wise use of the vote, may eventually do much for the cause championed by this volume.

A BIOLOGY OF FAMILIAR THINGS.

By George L. Bush, Allan Dickie and Ronald C. Runkle. American Book Co., New York. $1.92. 8¾ x 5¾; [6] + 695; 1939.

Most high school students feel that the reading of any textbook is labor. This volume goes as far as possible in minimizing cut and dried facts, presenting, as it does, material which is of greatest interest to young folks, and demonstrating biological principles along the way. This is done by showing how biology applies to man in health and sickness and in the keeping of gardens and of household pets. The economic importance of plants and animals is stressed, with particular reference to the control of pests and to the problems of conservation. For better than average students numerous assignments and experiments are suggested. There are also extensive lists of references.

DESERTS.

By Gayle Pickwell. Whittlesey House, McGraw-Hill Book Co., New York and London. $3.50. 11½ x 9; xiv + 174; 1939.

There is more plant and animal life in a desert than the average person usually suspects. This fact is brought very forcibly to one's attention by the beautiful photographs that illustrate this book. The author mentions the commoner plants and animals, typical of the deserts of the

Southwest, that spend their lives under rigorous conditions of existence, and explains how they are adapted to meet this struggle. But it is the illustrations that form the backbone of this work, the text being secondary, although interesting and essential.

OUR NATURAL RESOURCES AND THEIR CONSERVATION. *Second Edition.*

Edited by A. E. Parkins and J. R. Whitaker. John Wiley and Sons, New York; Chapman and Hall, London. $4.00. 9 x 5⅞; xiv + 647; 1939.

This volume follows the same plan of the earlier issue (*cf.* Q.R.B., Vol. 12, No. 2). In this edition, however, the 23 contributors have been able to give greater consideration to cross references and to eliminate duplication of material. All statistics have been brought up to date so far as possible. Some chapters have been reworked to fit changing conditions, and a new chapter has been added on the conservation of commercial fish. The editors point out that the greatest advance in any phase of conservation is in recreation, which involves, of course, hunting and fishing.

MANUAL OF BIOLOGY. *Part One, The Protozoa and the Plant; Part Two, The Metazoan Animals.*

By Douglas Marsland with the collaboration of Paul F. Brandwein. Henry Holt and Co., New York. $1.20 each. 11 x 8¼; Part One, ix + 176; Part Two, ix + 211; 1939 (paper).

Part One of this laboratory manual contains 24 exercises for the study of protozoa and the plant, and the second part has 25 exercises for metazoan animals. Both parts have sections on the sources of teaching materials and the pronunciation and derivatives of biological terms. The plan for centering the work around organisms and types rather than according to principles of biology was the outgrowth of many experiments in teaching large groups of students at Washington Square College, New York University.

SIR JOSEPH BANKS ISLANDS. *Part II. Reports of the McCoy Society for Field Investigation and Research. No. 3.*

Proceedings of the Royal Society of Victoria, Vol. 51, Part 1; 143–186; 1939.

This pamphlet represents Part II of the report by the expedition of the McCoy Society for field investigation and research, and describes the geology, vegetation, mollusks and fish associated with the Sir Joseph Bank Islands. For the most part, the plant and animal forms are quite similar to those of the neighboring mainland of Australia, and the only new forms described are one genus and eight species of mollusks.

SOIL AND HUMAN HEALTH. *A Call to Action.*

By Edgar J. Saxon. C. W. Daniel Co., London. 3d. net. 8½ x 5½; 8; 1939 (paper).

This little paper presents the substance of an address given to the Nature Cure Conference at High Leigh, Hoddesdon, Herts, England. A list is given of the necessary requirements for "restoring, maintaining and measuring the health and fertility of England's soil, or of soil anywhere in the wide world."

COLLEGE BIOLOGY. *Second Edition.*

By Walter H. Wellhouse and George O. Hendrickson. F. S. Crofts and Co., New York. $3.00. 8½ x 5½; viii + 391; 1939.

In the revision of this text (*cf.* Vol. 11, No. 4 for notice of first edition) corrections and changes, "taking advantage of the suggestions of students, teachers and other critics" have been made. A chapter on conservation has been added and the number of illustrations extended.

HUMAN BIOLOGY

ANCIENT ANDEAN LIFE.

By Edgar L. Hewett. Bobbs-Merrill Co., Indianapolis and New York. $4.00. 9⅛ x

6⅛; 336 + 32 plates + 1 folding map; 1939.

This completes a popular trilogy on ancient life in America. *Ancient Life in the American Southwest* and *Ancient Life in Mexico and Central America* are the first two volumes in the series on the American Indian race and its vital place in the cultural history of man.

Ancient Andean Life is divided into three parts. Part I deals with the history of man as a world-drama and the earth as a stage with the following principal stage settings: (1) desert areas, (2) great river valleys, (3) coast lands and continental islands, (4) intermountain plateaus, and (5) sterile lands with no history. The author makes a distinction between culture and civilization and defines culture as "the result of man's acceptance of nature as he finds it, . . . —not seeking to become the master, but remaining the child of nature; at one with her in mode of life, in aspiration, in worship—in short, in every phase of existence." A general archaeological picture of the world is given in which the Andean world has its niche.

Part II deals with the stage settings of the Andean world and the description and history of the Andean Indians of the present time, Inca time, Pre-Inca time, and remote time. Particularly amusing is the author's treatment of the Jivaro Indians. These Indians have quite a reputation as head-hunters; they also have novel ways of dealing with enemies. The author tells of their method of satisfying the gold-hunger of a Spanish governor—melted gold was poured down his throat.

In Part III (Retrospection and Conclusion) the author tells of his experiences of forty years work in the trenches as a "dirt" archaeologist. It is here that he expresses his opinions on the present study of archaeology to the effect that less academic verbalizing on the part of the professors and more spade archaeology would make for more productive results. The author also writes of the great archaeologists of the nineteenth century whose work kept his own interest aflame. Lastly, he speaks of the aims and values of this science.

SHEBA'S DAUGHTERS. *Being a Record of Travel in Southern Arabia.*

By H. St. J. B. Philby. With an Appendix on the Rock Inscriptions by A. F. L. Beeston. Methuen and Co., London. 21s. net. 9¼ x 6¼; xix + 485 + 47 plates + 1 folding map; 1939.

Sheba's Daughters is the account of the author's travels in Southern Arabia. The greater part of his journey lay in the little-known, undemarcated, unexplored territory of South-West Arabia between Sa'udi Arabia and the Aden Protectorate. The author was the first European to enter Abha, the capital of Najran, that much disputed frontier region between Sa'udi Arabia and the Yaman. He was the second European to visit Shabwa, but the first to make a thorough study of this ancient capital city of the Himyarites, its inhabitants, and the famous ruins of the Temple of Astarte. The first European to have visited Shabwa was Hans Helfritz who arrived there late at night and hurriedly quitted the city in the first hour of daylight escorted by its enraged citizens and a good deal of gunfire.

Philby's book represents an enviable record of travels and amazing explorations in South-West Arabia. In addition, the state of unrest among the peoples of that part of Arabia which is south of Sa'udi Arabia is vividly set forth. British imperial ambitions coupled with the Muslim's ingrained love of independence have produced that unrest; the Muslim in South-West Arabia envies the peace of Sa'udi Arabia and wishes for the intervention of Ibn Sa'ud in the South. Especially in Hadhramaut is there an undercurrent of restlessness, and particularly here do the people look to the coming of the Wahhabi King to help maintain the peace and order which the Muslim people are unable to maintain.

At the close of the book there is an excellent detailed map of the author's route. There is also an inset diagram on the same map of the Ruins of Shabwa. Although there is an index to the textual material, unfortunately there is no index to the map which is very detailed and hard at times to follow. There is also an appendix by A. F. L. Beeston on the inscriptions found by the author in his travels. This appen-

dix is followed by a word-index to the inscriptions.

Many excellent photographic plates occur throughout the text.

A Book of the 'Bounty.' *William Bligh and Others.*

Edited by George Mackaness. J. M. Dent and Sons, London; E. P. Dutton and Co., New York. 90 cents. 6¾ x 4¼; xv + 326; 1938.

The editor of Everyman's Library has done an important service in making easily available a considerable part of the most pertinent original documents regarding one of the most remarkable experiences in the history of humankind. To the human biologist there is no facet of the Bounty episode that is not of enormous interest and deep significance. Naturally everyone who has told the story of what happened, from the time it happened down to the present when every schoolboy knows something about it from the movies, has colored his narrative to a greater or smaller degree with the pigments of his prejudices. The present volume gives Bligh's side of the story. And in accomplishing this it does something more. It makes it possible for us to form in some degree a first-hand independent judgment as to what sort of man Bligh really was. The conclusion seems inescapable that he was not essentially different in kind from the general run of British naval officers of his time. The system deliberately encouraged pomposity, cruelty, and graft in the officers at the expense of the men. A just conclusion would seem to be that Bligh was no more of a knave than his peers in the service, who were all permitted and indeed encouraged to make as much as they could out of the business of victualling and otherwise supplying their ships. But quantitatively he appears to have been vainer, more conceited, and less capable of administering wisely the enormous power over other human beings vested in a naval commander by the system of his time, than the average.

Every Bounty-story fan, and they must be legion, will want this volume.

The Social Function of Science.

By J. D. Bernal. The Macmillan Co., New York. $3.50. 8¼ x 5⅝; xvi + 482 + 2 folding charts; 1939.

The subject of this book is a very broad one. Generally speaking it intends to investigate the relation of science to modern society and the social and economic developments in our time. Or, as the author, a physicist at the University of London, states in his preface: "This book is an attempt to analyse this connection; to investigate how far scientists, individually and collectively, are responsible for this state of affairs, and to suggest what possible steps could be taken which would lead to a fruitful and not to a destructive utilization of science." The task is not an easy one and one must admire, at any rate, the enormous amount of material which has been collected by the author in order to give such an analysis in different fields of science and in different countries. There is first an instructive historical chapter, completed somewhat in a later chapter on international science in modern times. It deals with science in the older industrial countries of Europe, in the United States and in the Far East, science and Fascism, and science and Socialism. Perhaps the author overestimates somewhat here and elsewhere the development of science and its possibilities in Soviet Russia. Other chapters analyze the present organization of science in schools and universities, the training of the research worker, the efficiency of scientific research with many a criticism; again other parts deal with the application of science, difficulties in financing research, the effect of war preparations on science, scientific communication and the function of scientific publication. These are only some of the points treated in the book. It is well documented.

Your City.

By E. L. Thorndike. Harcourt, Brace and Company, New York. $2.00. 8 x 5⅛; 204; 1939.

This book is intended to be a popular exposition of the author's investigation

on the General Goodness of Life in 310 communities and its measure or index G. The index G is the composite score of the well-being of a community and is derived from the rank held by the community relative to 37 items selected by the author. Among these items are included infant and typhoid death rates, numbers of telephones and automobiles, per capita expenditure for education and recreation, number of employed children, frequency of pauperism, the sale of certain magazines, and similar features about which some quantitative estimate can be made. The 37 items, given weights according to a criterion not explained here, were summed to arrive at a value of G which therefore appears to be more of a statistical pastiche than is the usual run of such indices. When the 310 cities are distributed according to the value of G the results show that Pasadena, Cal., Montclair, N. J., and Cleveland Heights, Ohio head the list while Columbus, Ga. and Charleston, N. C. are at the foot. The author proceeds then to correlate G with several other communal traits ranging from taxable wealth to the sex ratio of the population.

Incidentally, a number of the traits that the author correlates with G are already incorporated in G while others are implicit in some of the items that make up G. In the end, the analysis which certainly involves a tremendous amount of manual labor leads to results that, on the whole, are not very exciting and are pretty obvious to the intelligent reader, for whom this book is written.

REFUGEES. *The Annals of the American Academy of Political and Social Science, Volume 203.*

Edited by Francis J. Brown. The American Academy of Political and Social Science, Philadelphia. $2.50 (cloth); $2.00 (paper). 9¼ x 6¼; xv + 271; 1939.

Many well-known students of the social sciences have contributed to this number of *The Annals* dedicated to a discussion of the problems related to forced migration from one's country of birth or of residence. The twenty-two articles included here concern four aspects of forced migration: (1) the social elements responsible for the phenomenon; (2) the characteristics of the contemporary groups of political exiles; (3) the types of situations fared by the refugees in the countries to which they have repaired; (4) the means of alleviating the hardships of the refugees. On the whole, the subject is discussed objectively and mostly from the standpoint of the historical forces nvolved in the past and present instances of forced migration. As is to be expected, however, the articles that deal with the German-Jewish migration of today are written in a style calculated to arouse further the sympathies of the reader. With such articles excepted, this series is instructive inasmuch as a feeble attempt has been made to examine the question of exiles and refugees from a correct perspective. It may be added that no practical workable solution of the present problem has been advanced. An annotated bibliography of some of the very recent works on the refugee problem is also found in this number.

THE RACES OF EUROPE.

By Carleton S. Coon. The Macmillan Co., New York. $7.00. 9¼ x 6⅛; xvi + 739 + 46 plates; 1939.

This work, prepared to serve as a college textbook of physical anthropology, is concerned with the origins of the peoples of Europe. Moreover, the book has been written to expound an hypothesis. This is that "the present races of Europe are derived from a blend of (A), food-producing peoples from Asia and Africa, of basically Mediterranean form, with (B), the descendants of interglacial and glacial food-gatherers, produced in turn by a blending of basic *Homo sapiens*, related to the remote ancestor of the Mediterraneans, with some non-sapiens species of general Neanderthaloid form." Such is the basic idea that colors the exposition of the material. The first six chapters are dedicated to a discussion of the skeletal remains of man from those of the Pleistocene period to those of the Iron age. The fol-

lowing chapters are concerned with brief descriptions of the peoples now living in Europe. In general the subject is presented in a lucid if compressed manner. Included in the book are maps, original photographs and an adequate bibliography. It cannot be said that the author has sufficiently demonstrated his thesis. But it has, however, about as much plausibility as many other of the hypotheses that have been advanced on the subject.

THE SOUTH AFRICAN DRAWINGS OF WILLIAM J. BURCHELL. *Volume One. The Bachapins of Litākun. Collotype Reproductions with Descriptive Text.*

Edited by Helen M. McKay. Witwatersrand University Press, Johannesburg. £2 12s. 6d. 14 x 10½; xv + 21 plates; 1938.

William Burchell, naturalist and artist (1781–1863), visited Africa during the years 1810–1815. He made somewhat over 500 drawings and sketches during his travels. Some of these (20 colored plates and 96 vignettes) appeared in his work *Travels in the Interior of Sourth Africa*, which was published in two volumes in 1822–24. The Gubbins Trust of Johannesburg has undertaken the task of publishing groups of drawings, together with the artist's notes, from the remaining collections and here we have the first volume—collotype reproductions (4 colored), mostly of the natives with whom Burchell lived—issued in a very fine limited edition. All but three of the 21 plates are portraits and

were made for the purpose of showing every variety of countenance and feature . . . some [subjects] having more resemblance to the Guinea Negro, and others, on the contrary, to the Hottentot or Kora, with whom there frequently exists a real consanguinity. . . . I was much struck with the little agreement which *their proportions* have with those of a European head. The relative position or distances of several features, differed often in a most remarkable degree; and the head of Mollémmï would set all the rules of the art at defiance.

In his colored sketches the artist obtained the exact shades by preparing a kind of paint from *sibilo*, "a shining, powdery iron-ore of a steel-grey or blueish lustre" with which the natives smeared themselves.

SIBERIAN MAN AND MAMMOTH.

By E. W. Pfizenmayer. Translated from the German by Muriel D. Simpson. Blackie and Son, London and Glasgow. 12s. 6d. net. 8½ x 5¾; xii + 256 + 24 plates + 1 folding map; 1939.

This absorbing volume is an account of the author's two journeys into the far northeast section of Siberia. The expeditions were sponsored by the Russian Academy of Science and were made for the purpose of discovering and studying the frozen remains of the early Siberian mammoth, with nearly all the soft parts well preserved. These journeys took the author and his party through hitherto little known areas of the waste lands of northern Siberia, and the accounts of meeting with the inhabitants, and the study of their social and economic activities are quite as interesting as the description of the mammoth finds themselves. Two mammoths were studied *in situ*, and as far as possible, salvaged for further investigation. In addition to the study of the men and mammoths of this strange country, the author has included a discussion of the pertinent features of the climate, natural history, and the physical character of the terrain.

The work is well illustrated, completely indexed, and is concluded by Appendices I: The mammoth of Great Lyakhov Island; and II: The elks of North East Siberia.

SCHOOL AND COMMUNITY. *A Study of the Demographic and Economic Background of Education in the State of New York.*

By Julius B. Maller. The Regents' Inquiry, McGraw-Hill Book Co., New York and London. $3.50. 8¾ x 5¾; xiii + 360; 1938.

"The primary aim of this study is to throw light on the relationship between the cost and the character of education in the various communities of New York State and to portray the demographic and socio-economic background of these communi-

ties." To this end a great many statistical and demographic data are given in the single chapters which deal with dynamics of population, school population, characteristics of the population such as density, occupational pattern, unemployment. Other chapters take into account social factors, economic background and many other things that have a bearing upon educational policy. The material is carefully selected and gives much useful information from different points of view. In the chapter on social factors, for instance, valuable data are presented on crime and delinquency, cultural factors such as illiteracy, library facilities and magazine circulation, as well as data on health conditions and general and specific death rates in different communities. Several appendix chapters give in greater detail tabulated data for the single communities.

MY DAYS OF STRENGTH. *An American Woman Doctor's Forty Years in China.*
By Anne Walter Fearn. Harper and Bros., New York and London. $3.00. 8½ x 5¾; xiii + 297 + 15 plates; 1939.

Dr. Fearn belonged to the earliest crop of medical women in this country. Born in the deep South with an ancestry of aristocratic attitudes, she got her medical education only over sharp family opposition. Soon after taking the M.D. degree a wholly unforeseen set of circumstances sent her out to China. She intended to stay only a year or so. Actually she stayed until a short time before her death, which occurred soon after this volume came off the press.

She was a woman of remarkable intelligence and executive ability, as well as a wise and skilful physician. These qualities, coupled with unusual charm and social *savoir faire*, combined to make a career as notable for its material success and the joys of living that it included as for the well-doing that made it blessed by the hosts of Chinese and Europeans she healed and helped. She married a devout missionary, but herself could always take her religion or leave it alone. Her private hospital in Shanghai (the Fearn Sanatorium) appears to have been about as famous for its cocktails as for its medical services.

A notable book by a remarkable woman.

SEVEN LEAN YEARS.
By T. J. Woofter, Jr., and Ellen Winston. University of North Carolina Press, Chapel Hill, N. C. $1.50. 8⅜ x 5½; xi + 187 + 16 plates; 1939.

This book deals primarily with rural problems during the years of the depression from 1931 through 1937. The authors have had access to a wealth of material concerning the distress of the rural classes which are bearing the burden of rearing and educating 31 per cent of the nation's children with only 9 per cent of the nation's income.

> The improvement of rural life has been continuously agitated for many years. Country life commissions date back to the administration of Theodore Roosevelt, and farm aid has been the subject of countless investigations and organizations. Throughout this process the activities of the federal government in behalf of the farmer have increased, taking the form first of educational and advisory aid, then of the development of magnificent scientific bureaus and the extension service of the Department of Agriculture (p. 4).

However, not until the depression was the attention of the nation focused upon the importance of the rural situation. The single chapters give consideration to the manifold problems of the human elements involved as well as to the material side in terms of production and price structure.

RACE AGAINST MAN.
By Herbert J. Seligmann. Introduction by Franz Boas. G. P. Putnam's Sons, New York. $2.75. 8½ x 5¾; xii + 248; 1939.

To the multitude of books which have appeared in the past five years propounding the folly of race definition another has been added. The author explains the impossibility inherent in any attempt to define race; traces man from his earliest progenitors; believes heredity to be a matter of fate; upholds the hybrid as an asset to the world in both the animal and

human spheres; shows that every type of man has been responsible for some measure of the world's ethical development; and finally blesses America for being the world's true melting pot. The volume, at first glance, seems to present its wealth of material in an unbiased manner, yet, on close surveillance, it is possible to detect an undercurrent of emotional distrust of the social and political trends of the Nazi and Fascist regimes in Europe. Or, to put the matter less delicately, realism compels us to say that this book is essentially counter-propaganda.

THE MENOMINI INDIANS OF WISCONSIN. *A Study of Three Centuries of Cultural Contact and Change. Memoirs of the American Philosophical Society. Volume X, 1939.*

By Felix M. Keesing. University of Pennsylvania Press, Philadelphia. $2.50. 9¼ x 6; xi + 261 + 8 plates; 1939 (paper).

The author, in this monograph on the processes of cultural change, presents his research material covering three centuries (1634–1929) of cultural contact and change in the Menomini. The Menomini are one of the Central Algonquian tribes and as such represent "one sub-group within a great common area of culture and language found throughout the forest lands of the eastern and central parts of the United States and Canada." This monograph consists mainly of a survey of the ethnological and historical data concerning Menomini-white interaction during three centuries; the data are supplemented by the author's field investigations during a stay of over four months in the reservation community of the Menomini to observe the process of change as represented by the contemporary scene.

The author intends to visit the reservation again in order to bring fully up to date his study of contemporary life. This further study is made necessary in view of the adoption of the Indian Reorganization Act which aims at Indianization rather than assimilation.

GEORGIAN PORTRAITS.

By Percy Colson. Williams and Norgate, London. 8s. 6d. net. 8 x 5¾; 269 + 12 plates; 1939.

Eleven biographical essays about persons prominent in the British scene, followed at the end by an autobiographical self-portrait. The subject of each essay is introduced by some one other than the author. Only three of the subjects have any particular relations with science: Sir James Jeans—and Colson is rather more interested in Jeans's musical talents and activities than in his science; H. G. Wells; and the Bishop of Birmingham, Dr. Barnes. The book is entertaining. The author's prose has great beauty and charm. He does not like Mr. Wells much—says his intelligence is "slick and superficial"—and gives him a thorough, if urbane, lambasting. The attitude towards men, events, and things is throughout a bit on the wistful side. The world is no longer as nice a place as it once was before the advent of "our ugly, modern, *soi-disant* civilization." But the dissatisfaction is never bitter. "To everything," says Colson, "there is a season—a time to be born and a time to die. I have had a good innings, and I have not the faintest desire to make my century."

LIFE'S JOURNEY THROUGH TIME. *An Approach to Some Problems of Human Biology.*

By Alex. S. Gillespie. Pen-in-Hand Publishing Co., Oxford. 5s. net. 7¾ x 5½; 256 + 4 plates + 1 folding table; 1938.

In this book the author attempts to give schoolboys "something leading up to the biology of mankind," although the book is "especially concerned with population, war, and social problems." But isn't that rather too comprehensive for any volume of 200-odd pages, and isn't it asking a good deal of the understanding of almost any schoolboy or girl?

The book is divided into eight chapters, the first five of which discuss briefly the position of earth in space and the rise and spread of vertebrates culminating in the emergence of man and his rational mind. Chapter VI (pages 131 to 182) takes man

from the New Stone Age to the present. The two concluding chapters are "especially concerned with . . . social problems," for example, unemployment. There is a list of references for each chapter.

HOUSING REQUIREMENTS OF FARM FAMILIES IN THE UNITED STATES. *U. S. Department of Agriculture. Miscellaneous Publication No. 322.*

By Maud Wilson. Government Printing Office, Washington. 10 cents. 9⅛ x 5¾; 39; 1939 (paper).

This is a useful report suggesting desirable features of comfort in farmhouses. It is based on opinions and facts sent in by many farm homemakers and deals with a good many constructive ideas toward better housing conditions. "Recent studies of farm housing indicate that only a small proportion of rural families in the United States live in houses that have most of the features desirable for family life." Some main points of the contents may give a better insight of the material treated: general requirements of farmhouses, construction and orientation, entrance protection, heating, sanitary facilities, storage facilities, provisions for child care, etc. The regional variations in housing requirements of farm families are treated in a special chapter describing the main differences in 14 regions of the United States.

THE BANTU TRIBES OF SOUTH AFRICA. *Reproductions of Photographic Studies. Vol. III, Section 1, Plates I–XL. The Nguni. Introductory Article on the Nguni by N. J. Van Warmelo. The Ciskei and Southern Transkei Tribes (Xhosa and Thembu) by W. G. Bennie and a Select Bibliography by I. Schapera and W. G. Bennie.*

By A. M. Duggan-Cronin. Deighton, Bell and Co., Cambridge. 25s. net. 11¾ x 8¼; 57 + 40 plates; 1939 (paper).

Following a general discussion on the Nguni tribes, two sub-groups, Xhosa and Thembu pictorially presented in 40 excellent plates, are considered culturally and historically in two separate brief reports. There is a large bibliography on the Xhosa and Thembu which is divided into the following two sections: (1) history, ethnography, and modern conditions and problems, and (2) language and literature. Photographic studies of other Nguni tribes will appear in future sections.

RASSENKUNDE UND RASSENGESCHICHTE DER MENSCHHEIT. *Zweite umgearbeitete und erweiterte Auflage in zwei Bänden. Erster Band. Die Forschung am Menschen. Siebte Lieferung (Bogen 48–53).*

By Egon F. von Eickstedt. Ferdinand Enke Verlag, Stuttgart. RM. 7.50 (25 per cent less outside of Germany). 10¼ x 7; 96; 1939 (paper).

This number continues the discussion of the association of constitutional type with hormones, begun in the sixth *Lieferung* (cf. Vol. 14, No. 3), and begins the section on physiological group differences in man. As in previous numbers of this second edition, extensive revisions and additions have been made over the first edition. Numerous references are given.

VERHANDLUNGEN DER DEUTSCHEN GESELLSCHAFT FÜR RASSENFORSCHUNG. *Band IX. Vorträge gehalten am 17. und 18. September 1937 auf der 9. Tagung in Tübingen. Sonderheft zum XV. Jahrgang des Anthropologischen Anzeigers.*

Edited by B. K. Schultz. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. RM. 22.80. 10 x 6¾; [4] + 234 + 28 plates; 1938 (paper).

This volume contains a series of lectures given at the meeting in Tübingen on September 17 and 18, 1937. They deal with anthropology and morphology, newer results of chromosome research, twin studies, race history and some other items, predominantly from German material.

ZOÖLOGY

THE PHYLUM CHORDATA. *Biology of Vertebrates and Their Kin. A Revision of Vertebrate Zoology.*

By H. H. Newman. The Macmillan Co., New York. $3.60. 8½ x 5¾; xii + 477; 1939.

BIOLOGY OF THE VERTEBRATES. *A Comparative Study of Man and His Animal Allies. Revised Edition.*

By Herbert E. Walter. The Macmillan Co., New York. $4.00. 8½ x 5¾; xxv + 882; 1939.

In this revision of *Vertebrate Zoology*, which appeared in 1920 and has had considerable usefulness for supplementary reading in comparative anatomy courses, it was necessary to produce an almost entirely new book in order to incorporate certain changes desired by the author. As it now stands, the book presents the subject matter of the lecture part of a course in comparative anatomy (the laboratory work, dealing with comparative anatomy, system by system, is independent of the lecture course) with considerable additional matter for supplementary reading. The lectures cover the whole Phylum Chordata, with emphasis upon the evolutionary history of the group, the interrelations of surviving groups, general principles illustrated by the group, and significant aspects of their natural history. The volume is illustrated by 235 figures and is well indexed.

The second of these excellent texts first appeared in 1928 (cf. Q. R. B., Vol. 3, No. 3). Since that time eleven reprintings have been made. It now appears in revised form and entirely rewritten. Ninety-three pages have been added and something over 80 illustrations, so that there are now 736 figures. An excellent index is provided.

ELEPHANTS IN AFRICA.

By Frank Melland. Introduction by The Right Hon. The Earl of Onslow. Country Life, Ltd., London; Charles Scribner's Sons, New York. $3.75. 8½ x 5½; xiii + 186; 1938.

A careful and rather critical book about African elephants by an intelligent sportsman who has had a large amount of firsthand experience with them in the field. This is a book that every mammalogist will want to add to his library. The first five chapters deal with matters of behavior in general, and in particular with such things as mutual aid, seen in the other members of the herd helping a wounded comrade to escape. Chapters VI and VII deal with family life, breeding, childhood and adolescence. Two chapters (XII and XIII) are devoted to domestication, an important problem in Africa, on which real progress is being made. Other chapters are devoted to such topics as diet, control to prevent damage to crops etc., the degree of intelligence to be imputed to the elephant, native relations to elephants, and the much discussed mystery of sickness and death. On all these topics what the author has to say is restrained and sensible, great care being taken to make plain the distinction between what he knows of his own knowledge and what he has heard or read. Twelve full-page drawings by Stuart Tresilian add greatly to the charm of the book. There is a thorough index.

THE CHILDREN OF TANE. *Bird Life in New Zealand.*

By Mona Gordon. J. M. Dent and Sons, London; Whitcombe and Tombs, Christchurch, N. Z. 10s. 6d. net. 8½ x 5½; xii + 250 + 8 plates; 1938.

This book gives the history of bird life in New Zealand, from the time that Aotearoa was a country covered by virgin timber until the present day when modern civilization has, as usual, completely altered the topography of the island and as a consequence has appreciably affected the bird life. Many of Tane's children have disappeared or have become scarce. Fortunately sanctuaries have been instituted for the protection of some of the rare and unique species. These refuges are all described in detail. Tieke, Tauhou, Kokako, Titipounamu, the Kiwi, and the Huia are some of the birds about which the author relates interesting facts concerning their habits. As may be gathered from the native names, the book is filled

with Maori bird mythology and also with much material on the Maoris themselves. There is an index, a few color illustrations of birds, some photographs of the island, and a list of the scientific names of the birds mentioned in the book.

PHYSIOLOGICAL GROUP DIFFERENTIATION IN LYMNAEA COLUMELLA. *The American Journal of Hygiene Monographic Series, No. 14. By Joshua L. Baily, Jr. With a Foreword by Raymond Pearl. The Johns Hopkins Press, Baltimore.* $1.00. 9 x 5⅞; x + 133 + 2 folding tables + 2 plates; 1939.

Baily reports the results of an investigation on *Lymnaea columella* Say, the object of the inquiry being "to disclose the possibility of physiological races which were morphologically indistinguishable." He gathered two samples of snails, one from Centennial Lake, Fairmount Park, Pennsylvania and the other from a pond at Dumbarton, Maryland. These snails were bred under laboratory conditions and the longevity, mortality rate and fertility of the progeny were observed. The results of the investigation show that while the two groups of snails could not be differentiated morphologically yet they presented striking and significant differences relative to the physiological variables studied. The laboratory technique employed in this investigation is described in detail and the observations, also clearly presented, are accompanied by a brief but penetrating discussion regarding subspeciation and the formation of geographical races.

BATS. *By Glover M. Allen. Harvard University Press, Cambridge.* $4.00. 9 x 6; x + 368 + 30 plates; 1939.

There has long been a need for a good book about bats. Now we have it, and from the pen of a master. Allen has done a superb job, from both a literary as well as a scientific point of view. The bats are worthy of great biological respect for two primary reasons. They existed as "perfectly good" bats, not possibly to be mistaken for anything else, 20–25 million years ago in Eocene times. They represented then, as now, one of the most remarkable of all the adaptive divergences ever achieved by those remarkably adaptable creatures, the mammals.

The book is truly comprehensive. In its 21 chapters every aspect of the subject that arouses curiosity is authoritatively discussed. It is extensively and intelligently illustrated. It includes a bibliography of 14 pages. Altogether we cannot recommend this treatise too highly. It simply must be in every biological library.

BETWEEN PACIFIC TIDES. *An Account of the Habits and Habitats of Some Five Hundred of the Common, Conspicuous Seashore Invertebrates of the Pacific Coast Between Sitka, Alaska, and Northern Mexico. By Edward F. Ricketts and Jack Calvin. Stanford University Press, Stanford University, Cal.; Oxford University Press, London.* $6.00. 9 x 6⅛; xxii + 320 + 46 plates; 1939.

The fascinating life of a seashore loses some of its complexity as one reads this lively account of what two scientists found along the Pacific Coast without the aid of even a pocket magnifying glass. Common names are used as much as possible to supplement the Latin ones, and descriptions of forms and habitats are in nontechnical language. The many photographs and line drawings are a help to anyone wanting to identify his "catch."

About 500 common invertebrates of the west coast between Sitka, Alaska, and northern Mexico are discussed. The material is organized in such a way that the collector can run down his specimen from knowledge of its habitat alone, after all the easiest way for the beginner. An appendix gives references for the reader who wishes to go deeper into the field.

A LABORATORY INTRODUCTION TO ANIMAL ECOLOGY AND TAXONOMY. *A Laboratory*

Guide with Keys Prepared with Particular Reference to Fresh-Water and Terrestrial Habitats of the Deciduous Forest Region in North America.

By Orlando Park, W. C. Allee and V. E. Shelford. University of Chicago Press, Chicago. $2.00. 8 x 5½; x + 269; 1939.

This laboratory course offers an extremely interesting and stimulating introductory plan of study of natural history for field and laboratory work. Preceding the exercises there is a comprehensive introductory discussion on the interrelationship of animals with their environment. The main part of the book is given over to exercises which have been so arranged that they involve field work, identification of field forms, observation and experiment, and reading and reflection. There are two synoptic keys—one to phyla and the other to classes and orders. These are followed by a glossary of the technical terms used in the keys. At the end of each exercise there is a list of suggested reading. There is also a separate alphabetically arranged bibliographical section. There are two indexes—taxonomic and subject.

The Recent Mammals of Idaho.

By William B. Davis. The Caxton Printers, Caldwell, Idaho. $5.00. 9 x 6; 400; 1939.

This handsome volume describes the 141 different kinds of mammals to be found in Idaho. In addition to the account of species, there are chapters on the geography of the state, floral provinces, problems of distribution, and other matter pertinent to an understanding of the mammalian fauna with respect to its distribution, evolution, etc. The author has made a few systematic changes and described several new forms that will be of interest to the taxonomists. There are keys and distributional maps, a bibliography and an index. Also much material on life histories is given. So, all in all, this book represents a compendium of knowledge concerning mammals of this state and the surrounding territory. An altogether notable book.

Zoologica. *Scientific Contributions of the New York Zoological Society. Volume XXIV, Part 1, Numbers 1–5.*

New York Zoological Society, Zoological Park, New York. 85 cents. 10½ x 7; 63 + 8 plates; 1939 (paper).

The following papers are listed: (1) On *Sphyrion lumpi* (Krøyer), a copepod parasite of the redfish, *Sebastes marinus* (Linnaeus), with special reference to the host-parasite relationships; Ross F. Nigrelli and Frank E. Firth: (2) Notes on the functions of the forebrain in teleosts; R. G. Meader: (3) The Panama Canal as a passageway for fishes, with lists and remarks on the fishes and invertebrates observed; Samuel F. Hildebrand: (4) The cytology of the pituitary gland of two varieties of goldfish (*Carassius auratus* L.), with some reference to variable factors in the gland which may possibly be related to the different morphological types; Irving Levenstein: (5) Notes on plumage changes in the Quetzal; Lee S. Crandall.

Of Ants and Men.

By Caryl P. Haskins. Prentice-Hall, Inc., New York. $2.75. 9 x 6; vii + 244 + 15 plates; 1939.

The title of this book might give the impression that a comparison is made between man and ants but actually one finds very little of it. Instead, the book contains a delightful description, somewhat anthropomorphic in tone, of the social activities and probable social evolution of numerous genera of ants. Under such suggestive chapter headings as "Fascism or Communism?", "War," "Slavery," etc., the author limits himself in general to an account of certain aspects of the organization of ant society with but innocuous excursions into the parallels to be noted in human society.

Domestic Pests. *What They are and How to Remove Them.*

By L. Hunter. Foreword by Winifred Cullis. John Bale, Sons and Curnow,

London. 7s. 6d. net. 8½ x 5½; xii + 235; 1938.

In this book is given, briefly, the essential information concerning all household pests, both animal and plant, that plague the British housewife. For each pest, the material has been arranged under headings (habits, life history, harm done, prevention, eradication, etc.), and is accompanied by excellent black and white figures which show various stages in life history. Simple remedies for eradication as well as what to use in serious infestations are always given. An excellent list of references accompanies the description of each pest and the volume concludes with a glossary and an index.

BUSCHI: *Vom Orang-Säugling zum Backenwülster.*

By Gustav Brandes. Verlagsbuchhandlung Quelle und Meyer, Leipzig. RM. 4.80; (25 percent less outside of Germany). 9 x 5⅝; [6] + 135; 1939.

This is the life history of Buschi, an orang-outang who grew from infancy to adulthood under the care and observation of Professor Brandes, former Director of the Dresden Zoological Gardens and famous authority on anthropoid apes. In addition to his research on the morphological and physiological development of orang-outangs and on the question of the connection between the human race and the highest anthropoid apes in the light of his researches, the author has presented a story which, though basically scientific in nature, will appeal to all animal lovers. There are many excellent photographs.

A GRAPHIC SUMMARY OF FARM ANIMALS AND ANIMAL PRODUCTS. (*Based largely on the Census of 1930 and 1935.*) *U. S. Department of Agriculture. Miscellaneous Publication No. 269.*

By O. E. Baker. Government Printing Office, Washington. 10 cents. 9⅛ x 5¾; 88; 1939 (paper).

A presentation in graphic form of the number and value of the domestic animals and fowls and the honey-bee colonies of the United States as reported by the census of 1930 as well as by more recent special surveys. The value of the animal products (hides, beef, wool, milk, butter, cheese, eggs, honey, etc.) is discussed in relation to the fluctuations in the market due to changes in supply and demand.

JOURNAL DU CONSEIL. Vol. XIII, No. 3. *Conseil Permanent International pour l'Exploration de la Mer.*

Edited by E. S. Russell. Andr. Fred. Høst and Fils, Copenhagen. Annual subscription price 12 Kroner + Kr. 1.90 for mailing; single copies Kr. 4.50. 10 x 6¾; 147; 1938.

Two articles on plankton ecology appear in this number, one discussing the relationship between zooplankton and phytoplankton, while the other considers diurnal variation in breeding and feeding. Further articles include quantitative estimation of phytoplankton, determination of fat in plankton and herring, migration of halibut, and the relationship between wind and current. The last half of the journal is devoted to reviews and current bibliography on marine subjects.

WHAT SNAKE IS THAT? *A Field Guide to the Snakes of the United States East of the Rocky Mountains.*

By Roger Conant and William Bridges. Drawings by Edmond Malnate. D. Appleton-Century Co., New York and London. $2.00. 7½ x 5¼; viii + 163 + 35 plates; 1939.

The identification of snakes east of the Rocky Mountains is the primary purpose of this book. The authors hope to foster young herpetologists' interest in the natural history of these vertebrates by providing the groundwork for their investigations. This field guide contains not only black and white illustrations of the snakes but also a few notes on their habits and range. There is a chapter

concerned with snake venom, a glossary, and an index.

ILLUSTRATED KEY TO WEST NORTH AMERICAN PELECYPOD GENERA.

By A. Myra Keen and Don L. Frizzell. Stanford University Press, Stanford University, Cal.; Oxford University Press, London. 75 cents. 11 x 8½; 28; 1939 (paper).

This key to Pelecypod genera of western North America is amply illustrated to facilitate ready identification. There is a glossary and an index, the latter including the authors of the various generic names and their synonyms. Malacologists will find this key a labor and time saving device for the indentification of their specimens to the proper genus.

TYPENLEHRE UND UMWELTFORSCHUNG. *Grundlegung einer idealistischen Biologie. Bios, Band IX.*

By Friedrich Brock. Verlag von Johann Ambrosius Barth, Leipzig. RM. 4.20. 9¼ x 6¼; vii + 40; 1939 (paper).

The author, a pupil of Driesch and von Uexküll to whom he dedicates this treatise, discusses on the basis of the theory of von Uexküll and his own experimental investigations with the higher crustacea and *Buccinum undatum* the problem and methodology of an "idealistic" morphology. There are twelve illustrations and a bibliography.

BOTANY

THE WORLD OF PLANT LIFE.

By Clarence J. Hylander. The Macmillan Co., New York. $7.50. 10¼ x 7⅞; xxii + 722; 1939.

The author has written this book for the specific purpose of introducing the varied plant life of the United States to its citizens—the backyard gardeners, the windowbox gardeners, the countless community garden club members, the travelers, the college students who though familiar with microscopic work as presented in botany courses are unable to identify plant forms in the plant world about them, and the -ologists *ad infinitum* who see the whole of the plant world only in terms of their own specialities.

> There is, in the United States, an assortment of plant life equalled by few other countries .... Because of the almost riotous abandon of American topography, from the mountains of the far west to the eastern coastal swamps, and from the flat midwestern plains to the desert basins of the southwest, there is every conceivable type of habitat with its own peculiar forms of plant life.

Although this book is a source of detailed information on the life of almost every common plant, both native and naturalized in this country, it is neither confusing nor tiresome to read. The author has followed a simple classification and has omitted as much as possible of the scientific terminology with which text books are so painfully swamped. In addition there are over 400 excellent photographs and line drawings.

There are two appendixes: The first is a detailed check list of species arranged by phyla, classes, orders and families with both common and scientific names given. Appendix II is a reference list of general literature, manuals and identification books, and books dealing with more detailed aspects of plant life—(these latter are correlated with the chapters). There is also a large and complete index.

INTRODUCTION TO THE BOTANY OF FIELD CROPS. *South African Agricultural Series, Vol. 16. Vol. I., Cereals; Vol. II., Non-Cereals.*

By J. M. Hector. Central News Agency, Ltd., Johannesburg; Gordon and Gotch, London. £3. 10s. net. 9¾ x 6⅞; Vol. I. xi + 478 + xxxiv; Vol. II. vii + 479–1127 + xxxiii; [1938?].

Two important volumes for the student of botany, but more especially for the advanced worker in agronomy. The work is to be regarded as an "introduction" to this rapidly growing subject, bringing together a large amount of material, much of which can only be found in widely scattered sources. In spite of the size of the work, its scope is in breadth rather

than in detail. Nevertheless all the important phases in genetical analyses, cytology, physiology, etc., for each form are thoroughly discussed and wherever necessary details are included. "Crop ecology," a subject which the author feels is too vague at present for generalization, has been omitted.

The term 'field crops' is here used in a particulate sense: inclusively to incorporate all plants cultivated in the 'field,' *i.e.*, on arable land; exclusively to omit the plants of the garden, the orchard, the grove and the plantation. The distinction, however, is not absolute, since all 'cultivated' grasses are omitted and certain plants, such as cotton—regarded in certain areas as a 'plantation crop'—are included.

In the first volume the chapters are on the Gramineae—oat species (Avena), wheat species (Triticum), rye, barley, rice, millets, saccharum—the sugar canes—sorghums, and maize. The second volume is on the Liliaceae—onions and asparagus; the Moraceae—hemp and hops; the Polygonaceae—buckwheat family; the Chenopodiaceae—beet family; the Cruciferae; the Leguminosae; the Linaceae—flax; the Malvaceae—cottons; the Umbelliferae; the Convolvulaceae—sweet potato; the Solanaceae—potato, tomato, tobacco; the Cucurbitaceae; and the Compositae.

SHEEP AND TURNIPS: *Being the Life and Times of Arthur Young, F.R.S.* *By Amelia Defries. With a Preface by R. A. Butler and an Introduction by Montague Fordham. Methuen and Co., London.* 7s. 6d. net. 7¼ x 5¾; xviii + 235; 1938.

England's "Second Agrarian Revolution" of the late 18th and early 19th centuries laid the foundation for the England of well-tilled farms and fine livestock of today. Prominent among the men who did the spade-work of actual experimentation in agricultural methods and who helped formulate some of the legislation that encouraged good farming was Arthur Young, first Secretary to the Board of Agriculture. His interest, however, was not confined solely to agriculture. The broader aspects of a population's composition and the relation of the rural–urban ratio to a nation's prosperity also claimed his attention. He was a strong advocate of a census, publishing a paper in 1770 entitled *Proposals for Numbering the People.* His papers, and the journal of his travels through England and France, are sources for much of the material here, to which the author has added a brief but comprehensive sketch of the background of England's agrarian revolutions. The present biography gives a well-rounded picture of this pre-Malthusian thinker, sometimes called "the father of modern agriculture."

WONDER PLANTS AND PLANT WONDERS. *By A. Hyatt Verrill. D. Appleton-Century Company, New York and London.* $3.00. 8 x 5½; xiii + 296 + 16 plates; 1939.

A popularization that stresses the absolute necessity of plant life for the existence of all life on the earth, and describes the plant wonders used for food, clothing, shelter, beverages and other commodities, together with the plant giants, plant dwarfs, and other plant curios throughout the world. The reader is led on with the often repeated comment that curious as this plant may be, or valuable as that plant may be, the one about to be described is even more curious or more valuable than the preceding one.

The long bow is sometimes stretched to the breaking point. The statement that bacteria spores ". . . germinate and produce more bacteria even after being frozen in liquid air at a temperature of over four thousand degrees below zero . . ." seems to overlook the fact that absolute zero is usually thought by physicists to be at 273° below zero Centigrade (−459°F.).

Journalistic science at not quite its highest level is about the right price tag for this volume.

BACTERIA *the Smallest of Living Organisms. By Ferdinand Cohn. Translated by Charles S. Dolley. Introduction by Morris C. Leikind. The Johns Hopkins Press, Baltimore.* $1.00. 10 x 7; 44; 1939.

It was indeed commendable to re-edit this

classical paper that takes an important place in the history of bacteriology. It was originally published in 1872 and as early as 1881 an English translation was made by Charles S. Dolley, then a medical student at the University of Pennsylvania, who had studied for some years abroad and at once recognized the importance of the paper. This edition of his translation has not been changed, except for the correction of some misspelled names, but the present editor has added to the text a fine introduction on the life of the original author as well as of the early translator. When Ferdinand Cohn published his essay in 1872 entitled *Ueber die Bacterien, die kleinsten lebenden Wesen*, Koch was still an unknown physician. The history of bacteriology, writes the new editor, has been written largely by medical men and the emphasis on the rôle of the bacteria as agents of disease has caused their importance in the life cycle to be forgotten. For this reason Cohn's paper is of importance since no one before or after him has so brilliantly and clearly indicated the position of bacteria in the general economy of nature.

THE GARDEN OF LARKSPURS. *With Decorations.*

By L. H. Bailey. The Macmillan Co., New York. $3.00. 9¼ x 6⅝; viii + 116; 1939.

An important book for those interested in breeding and hybridizing larkspur. It belongs in the series which Dr. Bailey started sometime ago with *The Garden of Gourds* and followed up with *The Garden of Pinks*.

Information is given concerning soil, drainage, fertilizing and mulching, and location of beds necessary for the successful cultivation of larkspur. Aside from sections on the breeding and culture of delphinium, a key to significant species, and descriptions of species and varieties (113 varieties of 76 species), special attention is given to the following larkspur groups: Rocket, Forking, Bouquet, Garland, Candle and Red.

Leon H. Leonian contributes a chapter on diseases of delphinium and W. E. Blauvelt on insects and other pests. There are also 23 black and white drawings in the text, a frontispiece and endpiece in color, and a useful index.

FLORAL MORPHOLOGY. *A New Outlook with special reference to the Interpretation of the Gynaeceum. Volume Two with additional illustrations and Index for Volume 1.*

By E. R. Saunders. W. Heffer and Sons, Cambridge. 10s. 6d. net. 7¼ x 5; xiv + 609 + vii; 1939.

Continuing the scheme begun in volume one (see review in Q. R. B. vol. 13, no. 1), the author discusses 151 additional families of flowering plants, again placing his emphasis on the relation of the vascular ground-plan to the floral ground-plan, and the importance of keeping this in mind when dealing with problems of floral morphology. There are many illustrations. An index covering both volumes is included.

An appendix contains a reproduction of the author's exhibit at a recent British Association for the Advancement of Science meeting. Under the title *A Century's Challenge to Orthodoxy*, he presents a survey of the course taken by a point of view (the structural nature of the gynaeceum) which has been contrary to the traditional one. His citations extend from 1823 to 1923.

THE GROWTH AND NUTRITION OF WHITE PINE (PINCUS STROBUS L.) SEEDLINGS IN CULTURES WITH VARYING NITROGEN, PHOSPHORUS, POTASSIUM AND CALCIUM: *with observations on the Relation of Seed Weight to Seedling Yield. The Black Rock Forest Bulletin No. 9.*

By Harold L. Mitchell. The Black Rock Forest, Cornwall-on-Hudson, New York. $1.50. 9 x 6; vi + 135; 1939 (paper).

This report, including 27 tables and 22 figures, gives in great detail the experimental procedure and results obtained in carefully controlled cultural experiments in white pine seedlings.

Seedlings grown in *properly balanced* nutrient-sand cultures are far superior, as regards total weight, balance between root and shoot and, to a lesser degree,

root development, than the average nursery-grown seedling of the same age. . . . The results of chemical analyses revealed an exceedingly high degree of correlation between the internal (seedling) content of N, P, K and Ca, expressed either as milligrams . . . or per cent of dry weight . . . , and the external (solution) concentration of these elements.

These experiments were repeated in a series of field studies where all the nutrient elements, varied in the cultural experiments, were also varied individually and in several combinations. Only the more pertinent data from the field studies, however, are included in this report—in the section dealing with certain fundamental relationships.

EXPERIMENTS IN PLANT PHYSIOLOGY. *A Laboratory Textbook.*

By Walter E. Loomis and Charles A. Shull. McGraw-Hill Book Co., New York and London. $2.00. 9 x 6; xiv + 213; 1939.

This excellent laboratory manual is a revision of a portion of the authors' *Methods in Plant Physiology*, and is prepared especially for the use of beginning students. The problems are developed around the broad physiological processes in plants (growth, respiration, transpiration, photosynthesis, etc.), and are of such a variety as to meet the needs of numerous types of classes and courses. The manual does not supplement any particular text book, but rather gives a list of references for each of the chapter headings, as well as a list of general questions for each experiment.

The volume is well illustrated, both graphically and photographically, and contains a table of contents, a complete index, and an appendix listing numerous chemical solutions, formulae, preparations, and apparatus needed in the plant physiology laboratory.

ELEMENTS OF PLANT PATHOLOGY.

By Irving E. Melhus and George C. Kent. The Macmillan Co., New York. $4.00. 8¾ x 5⅝; x + 493; 1939.

In the writing of this elementary text three points were kept in mind: (1) many students have no intention of becoming professional plant pathologists but take the course as an aid to their work as farmers, teachers, or agriculturists, (2) the time allotted to the subject must be brief—not more than five hours for one quarter or four hours for one semester, (3) the availability of appropriate subject matter in sufficiently concise form. Emphasis is placed on parasitism in disease processes and the principles relating to control measures, coupled with the condensation and omission of unnecessary morphological and mycological data.

The volume is abundantly and well illustrated (259 figures) and contains a glossary, a list of 75 books dealing with some phase of plant pathology and a useful index.

CORRELATIONS BETWEEN ANNUAL PRECIPITATION AND THE YIELD OF SPRING WHEAT IN THE GREAT PLAINS. *U. S. Department of Agriculture. Technical Bulletin No. 636.*

By John S. Cole. Government Printing Office, Washington, D. C. 5 cents. 9¼ x 5¾; 40; 1938 (paper).

Data covering a total of 387 crop years at 19 field stations in the Great Plains are given of precipitation for the year ended July 31 and three indexes of yield of spring wheat. The primary study is made with an index of the average yields of about 30 plots representing low-, medium-, and high-yielding methods. Less detailed studies are made with the average yields of continuously cropped plots, a low-yielding method, and an average of yields on fallowed land, a high-yielding method.

The statistical data are arranged in 28 tables.

PLANT BIOLOGY. *An Outline of the Principles Underlying Plant Activity and Structure. Third Edition.*

By H. Godwin. The University Press, Cambridge; The Macmillan Co., New York. $2.25. 7½ x 5¼; x + 308; 1939.

The Universities of Oxford, Cambridge, and London have combined "in the interests of schools, to make uniform the scope of teaching for the biology of their respective 1st M. B. examinations." For this reason, in the 3rd edition (the book

was at first intended mainly for first year medical students) there have been additions in certain sections and new chapters on the fern plant, and reproduction by means of the flower and the formation of seeds.

THE RELATIONSHIPS BETWEEN CUMULATIVE SOLAR RADIATION AND THE DRY WEIGHT INCREASE OF NURSERY-GROWN WHITE PINE AND RED PINE SEEDLINGS. *Black Rock Forest Papers, Vol. I, No. 13.*

By H. L. Mitchell and R. O. Rosendahl. Black Rock Forest, Cornwall-on-Hudson, New York. 11 x 8½; 87–94; 1939 (paper).

PRELIMINARY NOTES ON A METHOD FOR THE PREVENTION AND CONTROL OF WHITE GRUB INFESTATIONS IN NURSERY SOILS. *Black Rock Forest Papers, Vol. I, No. 14.*

By H. L. Mitchell. Black Rock Forest, Cornwell-on-Hudson, New York. 11 x 8½; 95–98; 1939 (paper).

MORPHOLOGY

RECHERCHES SUR L'EMBRYOLOGIE DU SYSTÈME NERVEUX CENTRAL DE L'HOMME.

By André Barbé. Preface by A. Souques. Masson et Cie., Paris. 250 francs. 10 x 6½; 1938 (paper).

This work embodies the results of three years of investigation on the development of the central nervous system in the human embryo. The first part is devoted to a detailed description of the nervous system of each of the 52 embryos, ranging in age from 18 to 252 days; the second, to a study of each region of the human nervous system in its development from the beginning to the end of pre-natal life. Some 320 excellent photographic illustrations have been included to supplement the text. No figure is included which is not thoroughly described; and likewise, no major point of interest is discussed in the text without the use of a photograph as a special aid.

M. Barbé, in giving a general plan of development for the human nervous system, has given particular and detailed attention to the cerebral vesicles during the first month of intra-uterine life; to the lateral and median ventricles; to the development of the choroid plexus; to the formation of the anterior and posterior hypophesis; to the trapezoid area of His; to the cranial nerves (particularly the hypoglossal); and the spinal ganglia. The author gives a description of the primitive neural tube, and with the aid of several excellent figures, shows its two distinct (cephalic and spinal) portions. The cerebral region is quickly transformed into five divisions, or cerebral vesicles, which, Barbé finds, do not always develop along a longitudinal axis, but may follow three other distinct and separate patterns; namely, *apical*, *pontique* and *nuchale*. There have been found several morphological differences in the cerebral cortex not only from subject to subject, but even within the same individual. The variability of the date of appearance, the width and form of the fissures and grooves is of such magnitude as to make a generalization on the point impossible. One significant point in the work is that the fissure of Rolando, the appearance of which the classics place in the fifth month, has been found by M. Barbe to be clearly marked in several embryos in the third month of development.

FORM AND CAUSALITY IN EARLY DEVELOPMENT.

By Albert M. Dalcq. The University Press, Cambridge; The Macmillan Co., New York. $3.50. 8½ x 5½; [7] + 197 + 2 plates; 1938.

This book is a monograph covering—as Professor Dalcq expressly warns us—his special views on the early organization of the egg, and on the causes, the mechanics, of development. Out of the abundance of available data, the author has chosen to present those embryological facts which to him suggest a general theory of organismal development.

Believing that "the causes [of development] cannot belong to any other category than the intimate physical and chemical nature of the germ materials, and their particular situation at the stage considered," and admitting that the nuclear factors have not yet been sufficiently analyzed, Dalcq feels that the cytoplasmic factors may now be defined in concrete

terms. He concludes that the material bases of germinal organization lie in a two-fold chemo-differentiation: first, in a "cortical field" (the dorso-ventral field of chordates, or its equivalent), and, second, in a "spatial gradient" (the yolk gradient of chordates, or its equivalent). Typically the former is a gradient of some substance dispersed mainly through the cortex of the egg, with its maximum concentration at the animal pole; the latter is a gradient of some substance dispersed more generally throughout the cytoplasm, but decreasing from the vegetative pole. The interaction between the "formative" or cortical field and the "differentiation" or "general activity" field provides the functional basis of morphogenesis. "In my opinion," writes Dalcq, "the organization of the egg—or of the sperm—prolongs that of the germ concealed in the parent soma. . . . The prime factors responsible for morphogenesis are contained in the germ, and not imposed on it from the outside."

ANATOMY OF THE HUMAN LYMPHATIC SYSTEM.

By H. Rouvière. Translated from the French by M. J. Tobias. Edwards Bros., Ann Arbor, Mich. $4.00. 10¾ x 8½; ix + 318; 1938.

This is the English translation of the painstaking and exhaustive work of Rouvière's *Anatomie des Lymphatiques de l'Homme* (cf. Q. R. B., vol. 7, no. 4). Many first-class drawings illustrate the work. Since the study of the lymphatic system is very often given too little attention in the medical schools as well as in most of the anatomic textbooks, the translation will find many friends among anatomists and clinicians. "In addition to completeness in anatomical descriptions of the lymphatic apparata of the bodily organs," the translator writes in the introduction, "Professor Rouvière rarely overlooked an opportunity to direct attention to the regions where lymph nodes or lymphatics are intimately related to other organs or nerve trunks, and in many instances he has indicated the possible implications of such relationship."

THE BASIC MECHANICS OF HUMAN VISION.

By R. Brooks Simpkins. Chapman and Hall, London. 12s. 6d. net. 8½ x 5½; viii + 228 + 8 plates; 1939.

This book will be of great interest to the experienced ophthalmologist who alone is able to prove the theories of the author. In particular he is of the opinion that the early prescription of glasses has a weakening effect on the eyes and especially that their employment by the increasing number of children is a serious menace to general health. More and more persons otherwise physically fit become dependent upon an artificial method of sight-augmentation when by proper exercising of the eye muscles sight deterioration, in the author's opinion, can be checked. The book is illustrated by many drawings showing the different stages and functions of the visual mechanism. It is well written and deserves to be carefully examined.

THE EMBRYOLOGY OF FLEAS. *Smithsonian Miscellaneous Collections. Volume 98, Number 3. (Publication 3527).*

By Edward L. Kessel. Smithsonian Institution, Washington. 45 cents. 9⅝ x 6¼; 78 + 12 plates; 1939 (paper).

The author presents his researches on the heretofore little studied phase of the pulicine life cycle, namely, that of the embryological development. *Ctenocephalides felis* (Bouché) (the cat flea), *Nosopsyllus fasciatus* (Bosc.) (the common rat flea), and *Hystrichopsylla dippiei* Roths (a giant form found in nests of the wood rat *Neotoma*) were selected as subjects for this study. Together the three families represented by the subject species contain over four-fifths of the total number of genera belonging to the order *Siphonaptera*.

The microtechnique used in this study is described in the first part of the monograph. At the end of the text are twelve excellent plates containing 90 figures. There is an extensive bibliography.

GROSS ANATOMY. *A Brief Systematic Presentation of the Macroscopic Structure of the Human Body.*

By A. Brazier Howell. D. Appleton-Century Co., New York and London. $6.00. 9⅝ x 6½; vii + 403; 1939.

The decreasing amount of time allotted in medical schools to the study of gross anatomy has made it impossible for the student to assimilate all of the details. Voluminous texts and reference books increase the difficulty of sifting the trivial from the important. Howell's excellent condensation is an effort to overcome this handicap of the student. There is little consideration of physiology or histology, but necessary references are made to embryological derivation. Few illustrations are given, an antomical atlas being a required adjunct. The volume contains a very complete and useful index.

CHORDATE ANATOMY.

By Herbert V. Neal and Herbert W. Rand. P. Blakiston's Son and Co., Philadelphia. $3.50. 9 x 6; x + 467; 1939.

In essence this volume is a condensation of *Comparative Anatomy* (Q.R.B., vol. 12, no. 1) and contains the same excellent features of that work. However, the present material is such that it can be comfortably covered in the limited time allotted to comparative anatomy in the curriculum of the pre-professional student. It omits much of the detailed discussions of histology and embryology found in the earlier volume. This systematic study clearly describes and depicts the anatomical evidences of the evolution of the human body from lower forms.

FINGERPRINTS: *History, Law and Romance. By George W. Wilton. Foreword by Robert Heindl. William Hodge and Co., London, Edinburgh and Glasgow.* 12s. 6d. net. 8½ x 5½; xix + 317 + 11 plates; 1938.

These pages tell an interesting history of dermatoglyphics. However, an undue amount of paper (half of the book) is used over the petty argument as to who first suggested fingerprints as a method of criminal detection. The author gives the laurel to Dr. Henry Faulds. A complete survey is presented of fingerprint cases throughout the world. It is regrettable that so little space is devoted to the rôle of dermatoglyphics in anthropology.

ANATOMIE GÉNÉRALE. *Origines des Formes et des Structures Anatomiques.*

By H. Rouvière. Masson et Cie, Paris. 70 francs. 11⅛ x 7⅝; [4] + 192; 1938 (paper).

In this general anatomy the author stresses particularly the relation between the mechanics and the formation of the parts and organs of the body, and discusses, in some cases, modifications in the structure and their inheritance. Physicochemical influences are not treated in detail. The bibliography runs to 364 titles.

PHYSIOLOGY AND PATHOLOGY

PROTEIN METABOLISM IN THE PLANT.

By Albert C. Chibnall. Yale University Press, New Haven; Oxford University Press, London. $4.00. 9 x 6; xiii + 306 + 3 plates; 1939.

This detailed and highly technical book makes its appeal principally to plant physiologists and biochemists. Excellent reviews and criticisms of historical and recent work on protein metabolism of seedlings mark the early chapters, the work of Schulze and Prianischnikow being particularly stressed. In regard to the formation of glutamine, the author concludes from experiments in his own laboratory that this substance can be produced in limited amounts by primary protein decomposition, and that glutamine and asparagine can also have a secondary origin. It is emphasized "that transfer of nitrogen from protein to amides does not necessarily imply that formation of these amides is exclusively a matter of protein metabolism."

One sees the agricultural value of this work in a chapter on the proteins of pasture plants. The quality of various types of pasturage, and seasonal variation in quality is shown in several experiments.

The value of protein analysis is well demonstrated in a discussion of the amount of cystine necessary in sheep forage to produce a high quality fleece.

The last part of the volume reviews studies on leaf metabolism and its regulation. Within a few hours after leaf detachment, protein decomposition can be detected. However, judgment is reserved as to the reason for such metabolism. Several appendices present methods of analysis of impure leaf-protein preparations. There are 370 bibliographic references.

LES GROUPES SANGUINS. *Leur Application à la Biologie, à la Médecine et au Droit.*

By Ludwik Hirszfeld. Translated from the Polish by Hanna Hirszfeld. Masson and Cie, Paris. 30 francs. 7¾ x 5½; [4] + 169; 1938 (paper).

Professor Hirszfeld summarizes in this monograph the knowledge that has been acquired about blood-groups, particularly those aspects of the subject that pertain to practical problems of medicine, law, anthropology, and biology in general. The first two chapters are of an introductory nature and deal respectively with the physiological characteristics of the blood and with Mendelian inheritance. The author proceeds then to a more detailed examination of the subject and describes first of all the classification of blood-groups and their hereditary transmission. In the following chapters he discusses also in detail the significance of the observations made with reference to problems of establishing paternity, of detecting racial mixtures and of studying certain kinds of immunological reactions. The book closes with a chapter in which the author enumerates some of the problems which he believes are of great importance and deserve to be tackled immediately. Although there are available a number of good treatises on blood-groups, this is one of the most lucid and comprehensive expositions of the subject that has appeared to date. It reflects the author's long experience as one of the leading investigators in the field.

ANNUAL REVIEW OF PHYSIOLOGY. *Volume I.*

Edited by James M. Luck and Victor E. Hall. Annual Reviews, Inc., Stanford University P. O., Cal. $5.00. 8¾ x 6; vii + 705; 1939.

Undoubtedly the success attained by the *Annual Review of Biochemistry* (now in its eighth volume) has encouraged Dr. Luck and a group of physiologists to launch this annual. The members of the editorial committee are as follows: A. J. Carlson, J. F. Fulton, M. H. Jacobs, F. C. Mann and W. J. Meek. It is their hope that this new Review will supplement the invaluable service which has been rendered for many years by *Physiological Reviews* and the *Ergebnisse der Physiologie*. We have not thought of publishing exhaustive treatments of selected topics such as may be found in these journals. The *Annual Review of Physiology* will have a somewhat different function and will be of value to the reader, not because of its depth of penetration into stated subjects, but because of its breadth, through year by year resumés of the significant work in the entire field of physiology.

Twenty-four sections, written by well-known and authoritative investigators, treat such subjects as permeability, biological effects of radiation, growth, temperature regulation, physiology of the liver, blood, the spinal cord and reflex action, physiological psychology, kidney, etc. As in the *Review of Biochemistry* each section concludes with an extensive bibliography and the volume has both author and subject indexes.

YOU'RE THE DOCTOR.

By Victor Heiser. W. W. Norton and Co., New York. $2.50. 8 x 5½; 300; 1939.

The author wisely emphasizes the fact that the material in this book is not meant to be a textbook to replace the physician. It is not for the ill, the lame, or the blind, but for those individuals who are not normally under a doctor's supervision. Dr. Heiser's experience in public health work in this country and in foreign nations has given him a broad perspective of living conditions and standards of health throughout the world, and based on this experience he now proffers a bookful of sensible suggestions for a healthier and happier life.

Half of the volume considers the troubles between man and his food, and since we are omnivorous creatures, there is plenty of material for discussion. There are very few *verbotens* and no one need fear after reading this entertaining volume that his life will be spent hereafter in utter discomfort wondering what would be the proper thing to do. Since the author himself is still quite hale and hearty, it will probably pay us all to follow his advice.

FIGHTING FOR LIFE.

By S. Josephine Baker. The Macmillan Co., New York. $2.75. $8\frac{3}{8}$ x $5\frac{1}{2}$; [6] + 264 + 8 plates; 1939.

The theory and practice of child hygiene the world over is in a great measure due to the pioneering efforts of Dr. S. Josephine Baker. In this autobiography she has incorporated, in a delightfully readable manner, her experiences in (1) convincing her male colleagues that a hard-working woman has a place in the medical profession; and (2) in convincing this nation and the world that the most fruitful work in saving babies' lives is that which aims to prevent child diseases rather than that which aims to cure the pitifully diseased and half-dead forms of humanity. In the second undertaking, Dr. Baker inaugurated the principle of preventive medicine in child hygiene, with all its far reaching and fruitful results.

The volume is, in essence, the record of a free thinking American woman endowed with a conviction concerning her contribution to the world, and with the enthusiasm and persistence necessary for carrying that conviction to reality. The author's professional mode of thinking and her authoritative mode of writing have in no way been belittled by the spicy humor which adds so greatly to the interest of the book.

I. THE CENTER, THE GROUP UNDER OBSERVATION, SOURCES OF INFORMATION, AND STUDIES IN PROGRESS. *Studies From The Center for Research in Child Health and Development, School of Public Health, Harvard University. Monographs of the Society for Research in Child Development. Volume IV, No. 1 (Serial No. 20).*

By Harold C. Stuart and Staff. Society for Research in Child Development, National Research Council, Washington, D. C. $1.75. 9 x 6; xiv + 261; 1939 (paper).

This Center for Research in Child Health and Development was created some seven years ago mainly to provide the opportunity and material for investigation on the mental and physical development of children and on the factors bearing upon the phenomenon of growth. As the title indicates this monograph is the first of a series of publications from the Center and is concerned with its organization and method of operation. First of all, the growth of the children is measured and studied with the aid of anthropometric, orthopedic, roentgenographic and photographic techniques. The study of the factors influencing the growth is also approached from multiple angles since the inquiry concerns heredity, social and economic status, dietary habits and so on of the children. From the description given here it would seem that the investigation is conducted in the most ideal and thorough manner, and we look forward to the publication of the findings and results.

THE PATIENT AS A PERSON. *A Study of the Social Aspects of Illness.*

By G. Canby Robinson. The Commonwealth Fund, New York; Oxford University Press, London. $3.00. 9 x 6; xiv + 423; 1939.

This book presents the results of an investigation carried on in the Johns Hopkins Hospital in 1936 and 1937, in which the clinical study of 174 patients in the medical wards and dispensary was supplemented by a study of the personal and social factors in each case. The material is presented in this book in the form of a brief abstract of the case history of each patient, including a discussion of the adverse social conditions found, and the effects on the medical status of the patient when the social condition was modified or the patient's attitude improved. The ab-

stracts are segregated into chapters under the following headings: patients with circulatory symptoms, respiratory symptoms, digestive symptoms, diabetes, syphilis and epilepsy, and psychoneuroses. The final chapter is devoted to a discussion of the importance of treating the patient as a whole. There is a bibliography of 28 titles, and an index.

PERSONAL AND COMMUNITY HEALTH. *Fifth Edition.*

By C. E. Turner. The C. V. Mosby Co., St. Louis. $3.00. 8½ x 5½; 652 + 4 plates; 1939.

The present edition of this well-known college textbook on hygiene follows essentially the same order of exposition as that of the preceding ones. The author seeks to present a comprehensive picture of contemporary knowledge about individual and community health as well as the anatomical, physiological and general biological foundations on which this knowledge rests. The contents of this book therefore cover a wide field: the organ-systems and their function in health and disease, modes of infection and contagious diseases, personal hygiene and sanitation, and the several phases of public health work and administration. Although necessarily very sketchy in parts and written in a style that occasionally acquires an evangelical tone (*cf.* the discussion on alcohol), the book is more than adequate for its purpose. Each chapter ends with a short list of the more important publications on the subject treated.

LA MORT DES BRÛLÉS. *Étude Expérimentale.*

By Louis Christophe. Preface by Léon Binet. Masson et Cie, Paris. 40 francs. 9½ x 6½; 95 + 20 folding charts + 9 plates; 1939 (paper).

Important experiments were performed by the author in an attempt toward the solution of the problem as to the processes causing death several days after injury from burns. Clinical and histological studies were made both on dogs that had themselves been subjected to burns and those that had not been so injured but died after perfusion with blood from animals that had suffered a burn. The conclusion is that the toxic substance, although not sufficient to cause immediate death, is transmitted throughout the body by the blood stream, and when it reaches the brain causes injury to the vegetative centers, perhaps including the paraventricular and supraoptic nuclei of the anterior hypothalamus, from which the animals eventually die. The book is illustrated with photographs of apparatus and histological sections and tables showing the results of urine and blood tests on the experimental animals.

MEDICAL MICROBIOLOGY.

By Kenneth L. Burdon. The Macmillan Co., New York. $4.50. 8¼ x 5⅝; xii + 763; 1939.

Since this book is intended primarily for the medical student beginning microbiology, the author stresses the clinical rather than the technical aspects of the science—the ward work rather than the laboratory side—though there are chapters on classification and on laboratory procedure.

The student who has just learned or is learning anatomy will be pleased to find infectious disease here treated in the same way, that is, by body systems. All infections of the skin, whether due to mite, rickettsia, or coccus, are discussed in one section, instead of being scattered through the text according to taxonomic relations. Insofar as possible the rest of the body is handled similarly.

The appendices contain laboratory methods, sources of information in the literature, and study questions.

SO YOU'RE GOING TO STOP SMOKING!

By J. C. Furnas. Simon and Schuster, New York. $1.25. 7¼ x 5; vi + 97; 1939.

This amusing little book does not offer any sure-fire panacea for those who desire

to quit smoking "gaspers" or other forms of tobacco. The author himself belongs to the ranks of those who have sworn off the coffin nails but finds himself still consuming them. However, good common sense remedies are proffered and several ways are suggested to fit individual tastes and inclinations. Truths and untruths concerning the tobacco habit have been separated and a consensus of present medical knowledge is given a chapter of its own. Most of the material has been gleaned from a questionnaire sent to famous people and from the invaluable experiences of the author himself. We recommend this entertaining volume to all and sundry, whether they be tobacco addicts or not.

THE PHYSIOLOGY AND PHARMACOLOGY OF THE PITUITARY BODY. *Volume II.*

By H. B. Van Dyke. University of Chicago Press, Chicago. $4.50. 9 x 6; xiv + 402; 1939.

The present volume (for Vol. 1, *cf.* Q.R.B., Vol. 12, No. 3) begins where the first volume left off in 1935 and includes references to all important experimental work appearing in 1936 and 1937 and some 1938 reports. The author states that in the present volume "I have undertaken to meet the need of sifting and classifying the new data and concepts and of modifying the old by endeavoring critically to review recent work on the physiology and pharmacology of the pituitary body. A brief summary of my opinion of the present state of our knowledge has been added to each chapter." The material is arranged in ten chapters and in an appendix is a discussion of "The structural formulas and principal actions of hormones of natural origin." The bibliography (1,418 titles) represents 78 per cent of the articles which were considered.

MALARIA IN PANAMA. *The American Journal of Hygiene, Monographic Series, No. 13.*

By James S. Simmons, with the collaboration of George R. Callender, Dalferes P. Curry, Seymour C. Schwartz and Raymond Randall. Johns Hopkins Press, Baltimore. $1.10 net. 9 x 6; xv + 326; 1939.

The subject matter is presented in three sections. The first, which is entitled "Malaria on the Isthmus of Panama (1501–1938)," includes two chapters, one of which deals with the history of the disease in this locality from the time of the early Spanish settlements until the beginning of the Panama Canal, and the other with its prevalence throughout the Republic of Panama up to the present time. Part two, entitled "Malaria in the Panama Canal Zone (1904–1938)," is divided into five special chapters and the third part, which is entitled "Malaria in the military forces of the Panama Canal Zone (1911–1938)," is composed of four chapters devoted to a general consideration of the malaria situation which confronts the United States Army.

THE NEWER KNOWLEDGE OF NUTRITION. *Fifth Edition Entirely Rewritten.*

By E. V. McCollum, Elsa Orent-Keiles and Harry G. Day. The Macmillan Co., New York. $4.50. 8⅜ x 5⅜; ix + 701; 1939.

All those acquainted with previous editions of this important book will welcome its reappearance (the fourth edition has been out of print since 1935). It has been completely rewritten but there has been no change in the general plan of previous editions which represent

an attempt to interpret the meaning of the extensive experimental work relating to nutrition and described in numerous journals during recent years. Our purpose has been to present the subject matter in a form intelligible and useful to the large number of students, teachers, physicians, dentists, and others who are interested in being informed on the present knowledge of nutrition.

ANAIS DA FACULDADE DE MEDICINA DE PÔRTO ALEGRE. *Ano I, Fascículo 1, Julho a Setembro de 1938. Publicação trimestral.*

Universidade de Pôrto Alegre, Rio Grande do Sul, Brazil. 10¾ x 7¼; 303; 1938 (paper).

This is the inaugural number of the official organ for the publication of scientific investigations conducted in the Faculty of Medicine in Pôrto Alegre. It opens with a description of the school and a list of faculty members. The papers of greatest interest to biologists include discussions of hereditary diseases of the eye, by Corrêa Meyer; biotypology of the female, by Martim Gomes; modern aspects of criminology, by Celestino Prunes; new anatomical-physiological horizons in the circulation of the blood, by Guerra Blessmann. T. Mariante and M. Salis report a case of arterial hypertension and F. Ygartua a cranial tumor (Hand-Schüller-Christian's disease) in a two-and-a-half year old boy. The papers, published in Portuguese, are provided with English, French, or German summaries.

CHRONIC ARTHRITIS IN WILD MAMMALS. *Transactions of the American Philosophical Society. New Series, Volume XXXI.*

By Herbert Fox. University of Pennsylvania Press, Philadelphia. $2.00. 11¾ x 9¼; 76 + 12 plates; 1939 (paper).

More than 1700 skeletal analyses and autopsies of wild animals have revealed that chronic arthritis is prevalent in nature. Those having the most conspicuous lesions were found to be the macrosomic animals, while small-bodied mammals, as the rodents and bats, were free of any symptoms.

Studies of this nature, it is hoped, will afford some clue to the yet baffling etiology of arthritis in man. There are twelve plates showing the affected skeletal parts, but no bibliography as all this material is practically unique.

THE WISDOM OF THE BODY. *Revised and Enlarged Edition.*

By Walter B. Cannon. W. W. Norton and Co., New York. $3.50. 8½ x 5¾; 333; 1939.

Since 1932, when *The Wisdom of the Body* first appeared (*cf.* Q.R.B., Vol. 7, No. 3), much has been done in the experimental field which bears on the problems that Dr. Cannon so ably and interestingly discussed in that volume. The present edition has been revised to include all new pertinent data. The general reader with a liking for science will find this even more absorbing than the earlier book while the student of biological problems cannot neglect a treatise which so clearly and soundly knits together the results of innumerable physiological experiments to give us a picture of the stability of the body as a whole and the means whereby that organization is maintained.

BIBLIOGRAPHY OF REFERENCES TO THE LITERATURE ON THE MINOR ELEMENTS AND THEIR RELATION TO PLANT AND ANIMAL NUTRITION. *Third Edition.*

Originally compiled by L. G. Willis. Chilean Nitrate Educational Bureau, New York. $1.00. 11 x 8½; [4] + 488; 1939 (paper).

An extremely useful reference book for the student of nutrition problems. The present edition has almost double the number of abstracts and references (4628) which the second edition had. Besides the increase in subject matter certain changes in the text have been made to make the bibliography more useful. Mr. L. G. Willis, soil chemist at the North Carolina Experiment Station, originally compiled the material (first edition appeared in 1935).

LE SÉRUM NORMAL. *Propriétés Physiologiques.*

By Denis Brocq-Rousseu and Gaston Roussel. Masson et Cie, Paris. 140 francs. 9¾ x 6¾; 630; 1939 (paper).

The authors have continued their thorough and critical compilation of observations made on the properties of the normal blood serum. The first volume of the series, published in 1934 (noticed in Q.R.B., Vol. 9, p. 373), dealt with the physical properties. The present one includes practically every study made on the physiology, the bibliography containing almost 4000 titles. It is planned to continue this valuable reference work

with a third volume to treat the diastasic properties of this serum.

BIOCHEMISTRY

CHEMIE UND PHYSIOLOGIE DES EIWEISSES. *Edited by R. Otto, K. Felix and F. Laibach. Mit Unterstützung der Stadt Frankfurt a.M. Verlag von Theodor Steinkopff, Dresden and Leipzig.* RM. 6.75. 9¼ x 6¼; xii + 203; 1938 (paper).

This volume contains the lectures, together with the general discussions following them, presented at the Third Frankfurt Conference for Collaboration in Medical and Natural Sciences. The lectures are divided into three groups. K. Felix, W. Dirscherl, H. Gremels, H. Bennhold, and Th. Wagner-Jauregg discuss the purely chemical aspects of albumen. E. Abderhalden, W. Weichardt, R. Prigge, R. Otto and K. Laubenheimer have contributed papers on the rôle of albumen in immunity reactions. Various aspects of the rôle of albumen in metabolism and nutrition, and the culture of plants with a high albumen content are treated by K. Wetzel, C. Schöpf, F. Laibach, H. Fink, R. von Sengbusch, W. Heupke, and K. Zorn. Author and subject indices have been added.

CRYSTALLINE ENZYMES. *The Chemistry of Pepsin, Trypsin, and Bacteriophage.*

By John H. Northrop. Columbia University Press, Morningside Heights, N. Y. $3.00. 9 x 6⅛; xv + 176; 1939.

The general chemistry of enzymes is presented early in the book, followed by chapters on the properties, activation, isolation, and tests for purity of pepsin, trypsin, chymo-trypsin and their inactive precursors. The bacteriophage, though never crystallized, exhibits experimental results similar to those of the active enzymes. An extensive appendix details methods of preparation and estimation of these substances.

LE PHOSPHORE DES VÉGÉTAUX. *Son rôle dans l'énergétique cellulaire. II. Phosphore Lipidique.*

By E. Michel-Durand. Presses Universitaires de France, Paris. 25 francs. 10 x 6½; 84; 1939 (paper).

A continuation of the author's studies on plant phosphorus (*cf.* Q.R.B. vol. 14, no. 3). This section deals with the phosphatides (lipid P) and their derivatives in higher and lower plants, giving methods of extraction and physical and chemical properties. The formation, metabolism, and biological rôle of the phosphatides are adequately discussed.

TRAITÉ DE CHIMIE ORGANIQUE. *Tome XIV. Composés Azotés de l'Acide Carbonique. Composés Organoarséniés, Organophosphorés ou Organosiliciés.*

By Ch. Courtot, J. Doeuvre, A. Guillaumin and F. S. Kipping. Published under the direction of V. Grignard, G. Dupont, R. Locquin and Paul Baud. Masson et Cie, Paris. 200 francs. 9¾ x 6½; xix + 599; 1939.

This is the seventh volume of a 15 volume treatise to appear on organic chemistry. Like the preceding parts noticed in these columns, it maintains the high standards of scholarship of the work as a whole.

PROTEIN CHEMICAL STRUCTURE.

By Carl F. Krafft, 2510 Q Street, N.W., Washington, D. C. [4]; 1939.

ATOMIC OSCILLATORS.

By Carl F. Krafft, 2510 Q Street, N.W., Washington, D. C. [4]; 1939.

ORTHOHYDROGEN AND PARAHYDROGEN.

By Carl F. Krafft, 2510 Q Street, N.W., Washington, D. C. [2]; 1939.

SEX

CLASS FERTILITY TRENDS IN ENGLAND AND WALES 1876–1934.

By John W. Innes. Princeton University Press, Princeton. $2.00. 9 x 6; xiii + 152; 1938.

After hundreds of articles and books have been written about the differences in the reproductivity of the socio-economic classes and some English and American writers, particularly, have gone so far as to see the downfall of civilization as a consequence of this phenomenon, it now appears that maybe in the near future such class differences as there are will be considerably diminished. This is the aspect of the problem that Innes has mainly investigated and discusses in this monograph. The first half of the book is concerned with a description of the trend of birth-rates in England and contains a painstaking reexamination of the 1911 British Census Report on marriage fertility. Rearranging the original data in several ways brings out nothing new and serves only to reinforce the previous conclusions. The second part of the book presents the results of what is practically a continuation of Heron's well-known study. The author examines for the period 1909–1934 the birth rates of the districts of London. The main findings are that during this period the birth-rates have declined in all the districts, those of the poor as well as of the rich. But, during the period of observation, the differences between the poor and rich districts have become less and less marked so that it would seem that there is manifest a tendency towards equalization of the reproductivity of the socio-economic classes. With restraint to be admired the author expresses such a conclusion in very cautious terms.

BIOMETRY

DEMOGRAPHICAL DATA, CLEVELAND, OHIO, 1931–1937.
By Howard W. Green. Cleveland Health Council, 1001 Huron Road, Cleveland. $1.00. 11 x 8½; [4] + 248; 1938 (paper).

INFANT MORTALITY AND ECONOMIC STATUS. *Cleveland Five-City Area 1919–1937.*
By Howard W. Green. Cleveland Health Council, 1001 Huron Road, Cleveland. $1.00. 11 x 8½; [6] + 123; 1939 (paper).

In the first of these reports, the author presents for each year from 1931 to 1937 the vital statistics of Cleveland, Ohio. Following the order given by the U. S. Vital Statistics reports, the data included here concern general mortality, infant mortality and births. For some unexplained reason stillbirths have been omitted.

The second monograph is devoted to an interesting analysis of the trend in infant mortality as observed from 1919 to 1937 in 10 sections of Cleveland. These sections represent the subdivisions resulting from the ten-fold classification of the city area according to economic status. The findings, while not unique, bring into relief facts which have not always been given sufficient consideration. In the first place it is shown that the rate of decline in infant mortality has been higher in the poorer than in the richer districts. Secondly, it is observed that the neonatal (deaths under 1 month of age) mortality rate is about the same for all districts, independent of economic status, and has not altered significantly during the years from 1919 to 1937. The importance of this fact has never been sufficiently recognized although it has been pointed out by a number of investigators. Both publications give basic data of the kind that maybe some day will be available for all communities.

POPULATION AND FERTILITY.
By D. V. Glass and C. P. Blacker. Population Investigation Committee, London. 3s. 8½ x 5½; 101; 1939 (paper).

This booklet aims to inform the layman about the simpler and more common statistical methods employed to measure population fertility. It describes the basic data to be found in the vital statistics reports of various countries and discusses the additional information that would be desirable and useful to obtain. The authors have also included here the "age pyramid" of the populations of 12 countries and the recent figures regarding their population size, natality "reproduction rates" and world war dead (a very timely and instructive bit of information considering the present international situation). There is nothing contained in this work that is new to students of the

subject, but with respect to both contents and style the pamphlet well suits its purpose.

PRACTICAL ANTHROPOMETRY. *Second Edition.*

By Aleš Hrdlička. Wistar Institute of Anatomy and Biology, Philadelphia. $3.50. 10 x 7; xiv + 231; 1939.

The changes introduced in this second edition of Hrdlička's book consist mainly of the necessary additions to bring the book up to date. The description of the technique of measuring the living body has been amplified, sections on fingerprints and blood tests have been added as well as illustrative data on physical measurements. From its first publication Hrdlička's *Anthropometry* has been the standard textbook in most American institutions where physical anthropology is taught; therefore this second edition which does not substantially differ from the previous one will serve as well the purpose of teaching the art and principles of measuring the human body.

GRUNDBEGRIFFE UND HAUPTSÄTZE DER HÖHEREN MATHEMATIK *insbesondere für Ingenieure und Naturforscher.*

By Gerhard Kowalewski. Verlag Walter de Gruyter and Co., Berlin. RM. 5. 9 x 6⅛; 156; 1938.

The theory of determinants, vector analysis, limiting values, integral and differential calculus are all presented in this brief volume. Hence the treatment of each subject is necessarily limited. The author gives no applications of the material, confining his book to pure mathematics.

PSYCHOLOGY AND BEHAVIOR

PSYCHOLOGICAL FACTORS IN MARITAL HAPPINESS.

By Lewis M. Terman, assisted by Paul Buttenwieser, Leonard W. Ferguson, Winifred B. Johnson and Donald P. Wilson. McGraw-Hill Book Co., New York and London. $4.00. 9 x 6; xiv + 474; 1938.

This book contains a detailed account of the observations made by the author and his associates on the married life and reactions of 792 couples. These couples are a selected group so far as concerns social, economic and educational status. They represent the higher and more articulate classes. About 10 per cent of the couples were obtained through family relations institutes and therefore are, in the majority, maritally maladjusted. The material consists of questionnaires filled out by the husbands and wives. An elaborate and clever scheme was developed in order to ascertain that the responses of the husband or the wife did not affect those of the other partner and in turn to assure the subjects that the answers would remain unidentified. The questionnaire dealt with some 400 items regarding (a) personality characteristics as measured with the Bernreuter and Strong tests; (b) expressions of opinion about the ideals of marriage; (c) feelings about the married life and spouses of the subject; (d) parents and childhood of the subjects; (e) the sexual habits and manifestations of the subjects. From such data was derived an index of marital happiness which is not above criticism, although not as unsatisfactory as an index of its kind usually is. The relation of marital happiness to the numerous single items of the questionnaire was then studied. As one follows the analysis it becomes evident that the author is not content to fit theory to observation but has some preconceived notion which he seeks to prove. This is that the personality factor is of great importance in marital relations while the sexual element plays only a secondary rôle. In this respect one notes the author's efforts to explain away results which apparently are as significant as those he accepts without hesitation. The value of the study is therefore considerably weakened. For the time being the only conclusion which can be drawn from the observations outlined is that all the factors contributing to marital happiness have not yet been identified.

LANGUAGE AND SPEECH HYGIENE. *An Application of General Semantics. Outline*

of a Course. Monograph I. General Semantics Monographs.

By Wendell Johnson. Institute of General Semantics, 1234 East 56th St., Chicago. $1.50 (payable in advance). 10¾ x 8½; v + 54; 1939 (paper).

This is a general outline and abstract of the course *Speech Hygiene* which was presented by the author at the University of Iowa in the summer of 1938. Dr. Johnson became interested in General Semantics after reading Count Korzybski's development of this subject. Especially interested was he in the application of general semantics to his own particular field, namely, the scientific investigation of stuttering.

The author first makes some introductory statements concerning the study of word-fact relations as a basic problem in general semantics, the meaning of the orientational adequacy of word-fact relations, and the important point that the study of word-fact relations is not concerned with words or facts as such but with the relations between them as made by human beings and the degree of agreement among individuals in word-fact relations. Various quantitative techniques for the measuring of the degree of agreement are then given.

The process of abstracting is next explained and a modified form of Korzybski's "structural differential" (a schematic diagram of the process of abstracting) is shown. Following a discussion of labels, descriptions and inferences, the author turns the attention of the reader to the study of remedial general semantics and its far-reaching fields of application.

A short alphabetical list of literature is appended.

PSYCHOLOGICAL METHODS OF HEALING. *An Introduction to Psychotherapy.*

By William Brown. University of London Press, London. 7s. 6d. net. 8½ x 5½; vii + 224; 1938.

This book is designed as an introduction to the subject of psychotherapy. Essentially, it is a *credo*, presenting the author's evaluation, after twenty-five years of clinical practice, of the tenets of various European contributors to psychiatric thought, notably Freud, Jung, Adler, Janet, Charcot, Bernheim and Coue. No mention is made of American psychiatry. The chief psychotherapeutic procedures discussed are mental analysis, hypnosis, suggestion, autosuggestion and progressive relaxation, as they are used singly and in combination. There is very little discussion of the psychoses, and of the psychoneuroses, only hysteria, neurasthenia and compulsion neuroses are really considered. General problems of adolescence and maturity are covered in separate chapters. There is considerable philosophical digression, permeated throughout by the author's personal point of view.

As a text, the book seems unfortunate in its poor organization of subject matter, the incompleteness of its scope and the somewhat uncritical tendency to mingle opinion, conjecture and fact. There is a bibliography of 100 titles, and brief author and subject indices.

PERSONALITY DEVELOPMENT AND SOCIAL CONTROL IN TERMS OF CONSTITUTION AND CULTURE. *Three Lectures at The Tavistock Clinic, July 1937.*

By Ira S. Wile. Oxford University Press, London, New York and Toronto. $1.25. 8½ x 5½; [9] + 57; 1939 (paper).

This small book comprises three lectures delivered by Dr. Wile at the Tavistock Clinic in England. The first lecture entitled *Personality in Terms of Constitution*, is concerned with the general significance and meaning of constitution which is defined as "the aggregate of the physical and vital powers of an individual—physique or physical nature—also the aggregate of an individual's mental powers or qualities—temperament—or disposition." In the second lecture, *Personality in Relation to Culture*, the question of personal adjustments required in social living is discussed, and the various patterns of behavior which have been worked out for accomplishing this adjustment. The third lecture, *Social Control and the Prevention of Personality Disorders*, presents data on age, educational status, and vocational status in mental disease, and con-

siders various possibilities for social prophylaxis, religious, recreational, economic, etc. Dr. Wile concludes: "Social control should safeguard constitution by developing a more favorable culture."

THE PSYCHOLOGY OF MAKING LIFE INTERESTING.

By Wendell White. The Macmillan Co., New York. $2.50. 7¾ x 5¼; xv + 215; 1939.

This book is designed for the simple-minded layman with a sense of social failure, to whom all the successes he lacks are promised if he will only master the techniques herein outlined. These techniques comprise arousing curiosity, keeping up suspense, giving surprise, varying the voice and play of the features and varying the doing of things of every kind, a chapter being devoted to a detailed analysis of each. Having, by the application of these techniques, banished tedium and achieved his desired social goal, it should be possible for him to survey with equanimity the unwholesome behavior he has been spared, i.e. truancy, pyromania, alcoholism, gambling, etc. Many of the suggestions for furthering mental health put forward in the final chapters of the book are sound beyond controversy. A list of self-testing questions are appended.

There is little doubt but that the book will have a commercial success, and it is hoped that that of the readers will be as great.

THE MYSTERY OF THE BURIED CROSSES. *A Narrative of Psychic Exploration.*

By Hamlin Garland. E. P. Dutton and Co., New York. $3.75. 8¾ x 5¾; 351; 1939.

The author, through the aid of a medium, has been able to communicate with the spirits and has obtained their aid to locate crosses buried centuries ago by the Indians. There is still some mystery as to who buried them, but their location is real for wherever the spirits guided Mr. Garland and his cohorts, a cross was usually found (usually, because spirits apparently can err like the rest of us mortals). We are astounded at the apparent ease with which one can communicate with such personages as Doyle, Kipling, *et al.* We can't understand why this method hasn't been used before to inquire about unfinished work from departed scientists, or maybe to locate the burial place of the missing link.

Affidavits, lists of witnesses, and photographs of ectoplasmic forms make this work one necessary of serious consideration for those interested in psychic phenomena.

THE LOGIC OF MODERN PSYCHOLOGY.

By Carroll C. Pratt. The Macmillan Co., New York. $2.00. 8½ x 5¾; xvi + 185; 1939.

The impression received in reading this book is that it was written less with a view to influence the reader than to clarify the author's own thoughts on the subjects considered. The entire field of psychology is surveyed, the historical aspects, the points of views of different schools, and the different methodologies. The result is a re-evaluation of fundamental problems which, to this reviewer, seems somewhat academic, but which is understandable in the light of the author's attitude that

> psychologists need more than any other group of scientists the protection of cloisters, an atmosphere of detachment and leisure. They can be most useful to society by staying in their laboratories and libraries, there to remain until they can come forth with reliable predictions and well-tested applications. Those who are in the midst of earthquakes and battles do not discover the laws of motion or the reasons why men fight.

There is an index, but no formal bibliography.

HEREDITARY AND ENVIRONMENTAL FACTORS IN THE CAUSATION OF MANIC-DEPRESSIVE PSYCHOSES AND DEMENTIA PRAECOX.

By Horatio M. Pollock, Benjamin Malzberg and Raymond G. Fuller. State Hospitals Press, Utica, N. Y. $2.50. 9½ x 6½; 473; 1939.

This thorough study was undertaken in 1928 by the New York State Department of Mental Hygiene and the State Charities Aid Association. The cases investigated include first admission to the Utica State Hospital in 1928, 1929 and 1930, and comprised 155 manic-depressive patients and 175 dementia praecox patients. Detailed analyses of the family and environmental history of those two groups of patients were made. The expectation of mental disease among the general population of New York State was taken as the norm. The general conclusion with regard to each psychotic group is reached that "we do not as yet possess any exact statistical theory of inheritance, capable of describing the transmission of mental disease from one generation to another. We do feel justified in concluding, however, that there is some generalized basis, accounting for a family predisposition." There is a full, pertinent bibliography and an index.

SCIENCE AND PSYCHICAL PHENOMENA.

By G. N. M. Tyrrell. Harper and Bros., New York and London. $3.75. 8½ x 5½; xv + 379; 1939.

The object of this book is to present what has been accomplished in the field of psychical research by strictly scientific method. Classical evidence, taken particularly from the records of the English Society for Psychical Research, is presented for the reader, as well as the interpretations which have been imposed. The subject-matter is presented in five parts: I. Spontaneous Extra-Sensory Perception, II. Experimental Extra-Sensory Perception, III. Significance of the Evidence, IV. The Mediumistic Trance and V. Theoretical Aspect of the Mediumistic Trance. The book is well written and the subject-matter receives as fair and comprehensive a handling as it is possible for a believer to give. However, to the critical reader the gap between evidence and interpretation will seem wide. In an appendix, the libraries throughout the world where the Proceedings of the English Society for Psychical Research may be found are listed.

ALFRED ADLER: THE MAN AND HIS WORK. *Triumph over the Inferiority Complex.*

By Hertha Orgler. With Foreword by O. H. Woodcock. C. W. Daniel Co., London. 8s. 6d. net. 8½ x 5½; 241; 1939.

This book by a close personal associate and devoted disciple of Dr. Adler, is divided into three parts. Part I, Adler's Development up to his Creation of Individual Psychology, presents personal data on Adler's life and a brief account of his break with Freud. In Part II, the tenets of Individual Psychology are discussed in a rather general way. Part III, the Application of Individual Psychology, is concerned with the importance of Adler's views for education and for psychotherapy. A chapter is devoted to describing the dissemination of Adler's views throughout Europe and the United States.

The book is written with more fervor than objectivity, and seems inadequate both as a biographical contribution and as a technical exposition. A complete bibliography of Adler's writings is appended.

THE SOLUTION OF MULTIPLE CHOICE PROBLEMS BY CHIMPANZEES. *Comparative Psychology Monographs. Volume 15, Number 3. Serial Number 75.*

By Kenneth W. Spence. The Johns Hopkins Press, Baltimore. $1.00. 10 x 6¼; 54; 1939 (paper).

By the simplification of previously used standard techniques in testing the behavioristic adaptation of chimpanzees, the author has been able to arrive at the analysis of the basis of solution of several problems of multiple choice, as well as the nature of the reaction tendencies exhibited prior to solution. With 17 chimpanzees whose ages ranged from 2 to 22 years, it was found that all solved the problems about equally well. The problems represented a graded series in difficulty, yet all were approached and solved by essentially the same behavioristic procedure. The relearning of a solution after an intervening period in which several other problems were solved, required only about one sixth the number of trials as the original learning period required.

HABIT CLINICS FOR CHILD GUIDANCE. *U. S. Department of Labor. Bureau Publication No. 135. (Revised 1938).*
By D. A. Thom. Government Printing Office, Washington, D. C. 15 cents. 9¼ x 5¾; iii + 97; 1939 (paper).

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

THE MARCH OF MIND. *A Short History of Science.*
By F. Sherwood Taylor. The Macmillan Co., New York. $3.00. 8½ x 5½; xiv + 320 + 14 plates; 1939.

This book could just as aptly be called "the development of the scientific method." In the opening chapters we see men struggling with magic to explain the natural world; then, further along, the scientist of the Middle Ages combats theology, and finally, championed by Da Vinci, Newton, Descartes and Darwin, the scientific method triumphs. In the author's words, "the religious man today is not troubled by a farrago of fables nor by the necessity of literal adherence to a book. If he finds the Kingdom of Heaven, it is within him."

Aside from a tendency to make theology the villain, the author has given a well-rounded picture of the growth of twentieth-century science, the changing attitude of men toward careful observation and experimentation. Eastern and Arabian science appears in its proper relation to European culture, instead of, as is more usually the case, being relegated to a few lines. In the later chapters, the histories of various specialties are told, for example, the study of sound, light, plant and animal physiology. The material, however, is general, and the appeal of the book should be wide. It is relatively non-technical.

SCIENCE IN PROGRESS.
Edited by George A. Baitsell. Foreword by Harlow Shapley. Yale University Press, New Haven; Oxford University Press, London. $4.00. 9¼ x 6¼; xiii + 322; 1939.

This volume contains a series of lectures given in 1937 and 1938 at the Society of Sigma XI by some ranking scientists who describe here the results of their researches for a larger public. Thus reports are delivered on the latest progress in breaking down the atom (E. O. Lawrence); the separation of isotopes and their use in chemistry and biology (H. C. Urey); the recent advances in the study of viruses and virus diseases (W. M. Stanley and L. O. Kunkel); the functions of vitamins and hormones (K. E. Mason and R. R. Williams); and internal secretions in reproduction (Edgar Allen). There is another chapter on recent developments in our knowledge of chromosome structure (T. S. Painter); a new report on measuring electric potentials of the human brain (E. N. Harvey); and finally a review on animal metabolism: from mouse to elephant (Francis G. Benedict). The book closes with a list of references to each chapter, and an index.

SOMETHING SURPRISING.
By Gladys Adshead. Pictures by Helen Rinald. Oxford University Press, London, New York and Toronto. $1.00. 6 x 7¼; 69; 1939.

The author of this delightful little volume has shown a real talent for writing stories for children; stories which are scientifically correct and at the same time interesting and readable for the 8 to 12 year olds. In the 68 pages Miss Adshead has presented the drama of evolution from the formation of the earth, and the advent of life upon the earth down to the appearance of man as an intelligent and inventive animal. For those who are being introduced for the first time to the wonders of evolution, this little book will truly reveal "something surprising."

The line drawings by Miss Rinald will aid considerably in fixing in a child's mind the form of the plants and animals that have inhabited the earth through ages past.

UNDERSTANDING OUR ENVIRONMENT. *An Introduction to Science.*

By John C. Hessler and Henry C. Shoudy. Benj. H. Sanborn and Co., Chicago and Boston. $1.80. 8 x 5½; ix + 661; 1939. This book is intended to develop in students of junior-high-school age a curiosity about the world around them. "General-science" topics of all types are discussed briefly and references to further reading given. The practical aspect of science is stressed. Heat is considered from the standpoint of choosing the proper heating system for a building. The ideas of energy and friction, for example, are illustrated by the motion of a streamlined automobile.

There are 19 chapters divided into several problems, with study questions and notebook material for each.

THE PRICES OF BIOLOGICAL BOOKS IN 1939

By RAYMOND PEARL AND MAUD DEWITT PEARL

Department of Biology, School of Hygiene and Public Health, Johns Hopkins University

WHEN the QUARTERLY REVIEW OF BIOLOGY began publication in 1926 the custom was inaugurated of reporting at the end of each volume on the cost of the books that had been reviewed in its columns during the year. The present paper, therefore, is the fourteenth of these reports on the prices of biological books. The prices of foreign books have been converted into dollars on the basis of the exchange at the time the books were received. Table 1 shows the findings for 1939, arranged in the customary manner.

The total number of pages reviewed in 1939 is 179,601, an increase of 30,555 pages, or 20.5 per cent over 1938 and an increase of approximately 118 per cent over 1926, the year in which these tabulations began. In the fourteen years of the QUARTERLY REVIEW's history the books reviewed in these columns have aggregated a total of 1,804,265 pages. To American buyers these cost in the aggregate a total of $19,300.09, leading to an average price per page for the total of 1.070 cents. The weighted average cost of 0.941 cents per page for all the books reviewed in 1939 is 13.2 per cent lower than that for all the books reviewed in our columns during the preceding thirteen years 1926–1938 inclusive, taken as a bulk total. It is even lower than the corresponding average for 1938 of 1.024 cents per page by 8.1 per cent. The 1939 average price per page for all books reviewed is 14.2 per cent lower than the corresponding figure for 1926, which was 1.097 cents. The general picture presented by the 1939 summary is clearly of a continuation of the lowered prices that began with the 1937 report. Furthermore, the rate of the decline in biological book prices seems to be accelerating. The American biologist buying books in 1939 got off quite easily, as compared with other years, so far as may be judged from our review samples. We make no prediction as to the further continuance of this sharp decline in prices. Such prophecy would be hazardous in any case, and particularly in the presence of another World War, in which the level of biological book prices will play no important part in either strategy or tactics.

In 1939 Germany stayed in her customary position at the head of Table 1, as the source of origin of highest prices for biological books. And, in general, all the sources of origin stood this year in about their usual order, except that the sample of British Government publications jumped up into a position actually above that of either British-American books or the books published in Great Britain by commercial publishers. The average price per page of German books was actually 6.9 percent *lower* in 1939 than in 1938. It is impossible to say whether this apparent lowering has any real significance, because of the sampling errors involved that cannot be precisely evaluated. But probably no one will fail to be impressed

by the fact that back some forty years ago, say, when German scholarship and *Kultur* generally did have a great, and on the whole beneficent, influence upon the intellectual life of the world, the general level of its book prices was not so widely

TABLE 1

Prices of biological books, 1939

ORIGIN	TOTAL PAGES	TOTAL COST	PRICES PER PAGE
			cents
Germany	7,389	$159.40	2.16
Other countries	4,306	63.63	1.48
British Government	980	12.73	1.30
British-American	15,757	172.70	1.10
Great Britain	16,470	167.76	1.02
United States	116,068	1,041.14	0.90
France	9,709	60.91	0.63
U. S. Government	8,922	12.39	0.14
Totals and weighted average, 1939	179,601	1,690.66	0.941
Totals and weighted average, 1926–1938 incl.	1,624,664	17,609.43	1.084

the absolute and relative changes in price from 1938 to 1939 and from 1930 to 1939.

The average prices per page of our samples of biological books from every origin except the British Government were *lower* this year than in 1938, by amounts ranging from about 2 per cent for books commercially produced in Great Britain to 32 per cent for the "Other countries" publications. But the average price of these "Other countries" books was still more than 52 per cent higher than ten years ago in 1930. British-American books, coming in direct competition with those published in the United States, continued and increased, both absolutely and relatively, the decline in average price noted last year. French books showed a decline in average price per page of 12.5 per cent in 1939 as compared with 1938, but was still up 34 per cent above 1930. The 1939 average price per page for biological books published commercially in the United States was over

TABLE 2

Comparison of the prices of biological books for the decade from 1930 to 1939

ORIGIN	AVERAGE PRICE PER PAGE										CHANGE + OR − FROM 1938 TO 1939		CHANGE + OR − FROM 1930 TO 1939	
	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	Absolute	Relative	Absolute	Relative
	cents	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*per cent*	*cents*	*per cent*
British-American	1.91	2.27	1.48	1.29	1.45	1.53	1.81	1.44	1.16	1.10	−0.06	−5.2	−0.81	−42.4
Other countries	0.97	1.53	1.02	0.85	0.86	1.20	2.26	0.86	2.18	1.48	−0.70	−32.1	+0.51	+56.2
Great Britain	1.13	1.19	0.89	0.66	0.96	0.84	0.94	1.27	1.04	1.02	−0.02	−1.9	−0.11	−9.7
United States	1.09	1.05	1.00	1.01	0.93	0.90	1.03	0.93	0.96	0.90	−0.06	−6.3	−0.19	−17.4
Germany	1.82	1.75	1.60	1.43	1.89	2.04	1.84	1.95	2.32	2.16	−0.16	−6.9	+0.34	+18.7
British Government	1.19	1.03	1.45	1.39	0.89	0.50	1.62	0.34	0.45	1.30	+0.85	+188.9	+0.11	+9.2
France	0.47	0.69	0.60	0.74	1.00	0.86	1.05	0.85	0.72	0.63	−0.09	−12.5	+0.16	+34.0
U. S. Government	0.30	0.28	0.36	0.17	0.18	0.11	0.21	0.16	0.17	0.14	−0.03	−17.6	−0.16	−53.3

disparate from that of other countries as it has been during the last 15 years.

Following the custom inaugurated some years ago Table 2 shows the price trends of books published in various countries during the decade from 1930 to 1939 and

6 per cent lower than the 1938 price, and more than 17 per cent lower than in 1930. The United States Government still continues to disseminate scientific information at a price to the consumer well below any other source known to us. In 1939

the average price per page was 17.6 per cent lower in 1939 than in 1938, and over 53 per cent lower than in 1930. American biologists, of course, pay their due share of the taxes that make this beneficence possible, in last analysis. But, in all fairness, it is probable that most of them will feel that the part of their tax dollar that is spent in this way is much more usefully and wisely spent than a lot of the rest of it.

TABLE 3

Average biological book prices over the fourteen year period, 1926–1939 inclusive

ORIGIN	TOTAL PAGES	AVERAGE PRICE PER PAGE
		cents
Germany	180,357	1.643
British-American	130,523	1.502
Other countries	56,617	1.377
Great Britain	150,016	1.026
United States	1,074,598	1.009
British Government	10,199	0.948
France	142,561	0.692
U. S. Government	59,394	0.213
Total and weighted average	1,804,265	1.070

Table 3 sums up the whole fourteen years experience of the QUARTERLY REVIEW.

It is evident, from what has now grown to be a substantial sample, that during the past fourteen years biological books from all over the world taken together have averaged to cost the American biologist very close to a cent a page, taking good, bad, and indifferent together. Furthermore it is plain that the sources of origin of these books fall into three fairly sharply defined groups relative to unit prices to the American buyer. In the first or relatively high priced group fall books in the British-American, Germany and "Other countries" categories of origin. The primary reason why the British-American books fall in this category is because they carry an import duty charge, paid on the sheets manufactured in England but issued here by an American branch house. The next or medium priced group includes the United States, British Government, and Great Britain (commercial publishers). None of the books in this category carry import duty charges in the prices here tabulated, because in the case of the British books the English prices are used. Actually an American buying these books would have to pay duty. This would then, in fact, throw them into the same group as the British-American publications. Finally the third or relatively low price group includes books published in France and by the U. S. Government.

The reader should bear in mind that these reports are based on small samples of books in general and, for some countries, on small samples of the biological books published. He should therefore be cautious in applying conclusions drawn from this material to the general domain of book prices.

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